CHAPTER 8
ENGINE REMOVAL AND REPLACEMENT

GENERAL

Procedures for removing or installing an aircraft engine usually vary widely with the type of aircraft and the type of engine. Thus, no single list of instructions can be provided as a guideline for all engines. Because of the many types of engine installations and the large number of design variations within each type or category, representative examples have been selected to illustrate the most typical installation procedures for reciprocating, turboprop, and turbojet engines.

The radial and the opposed engines are used to describe and represent general and typical procedures for all reciprocating engine buildup, removal, preservation, storage, and installation. Although these two types have been included to ensure adequate coverage of engines used in both heavy and light aircraft, much of the information and many of the procedures presented in the discussion of radial engines are applicable to opposed-type engines. Only the significant differences between the two types are included in the discussion of opposed-type engines.

It should be emphasized that while procedures for specific engines and aircraft are included in this chapter, many pertinent or mandatory references have been omitted because of their irrelevance to a general discussion. For this reason, always reference the applicable manufacturer's instructions before performing any phase of engine removal or installation.

REASONS FOR REMOVAL OF RECIPROCATING ENGINES

The following paragraphs outline the most common reasons for removing and replacing a reciprocating engine. Information to aid in determining engine conditions that require removal is included; however, in every case, consult applicable manufacturer's instructions as the final authority in establishing the basis for engine replacement.

Engine Life Span Exceeded

Engine life is dependent upon such factors as operational misuse, the quality of manufacture or overhaul, the type of aircraft in which the engine is installed, the kind of operation being carried out, and the degree to which preventive maintenance is accomplished. Thus, it is impossible to establish definite engine removal times. However, on a basis of service experience, it is possible to establish a maximum expected life span of an engine. Regardless of condition, an engine should be removed when it has accumulated the recommended maximum allowable time since last overhaul, including any allowable time extension.

Sudden Stoppage

Sudden stoppage is a very rapid and complete stoppage of the engine. It can be caused by engine seizure or by one or more of the propeller blades striking an object in such a way that r.p.m. goes to zero in less than one complete revolution of the propeller. Sudden stoppage may occur under such conditions as complete and rapid collapse of the landing gear, nosing over of the aircraft, or crash landing. Sudden stoppage can cause internal damage, such as cracked propeller gear teeth, gear train damage in the rear section, crankshaft misalignment, or damaged propeller bearings. When sudden stoppage occurs, the engine is usually replaced.

Sudden Reduction in Speed

Sudden reduction in engine speed can occur when one or more of the propeller blades strike an object at a low engine r.p.m. After impact, the foreign object is cleared and the engine recovers r.p.m. and continues to run unless stopped to prevent further damage. While taxiing an aircraft, sudden reduction in speed can occur when the propeller strikes a foreign object, such as a raised section in the runway, a tool box, or a portion of another airplane. Investigation of engines on which this type of accident occurred has shown that generally no internal damage results when the r.p.m. is low, for then the power output is low and the propeller will absorb most of the shock. However, when the accident occurs at high engine r.p.m., shocks are much more severe. When sudden reduction in r.p.m. occurs, the following action should be taken:

(1) Make a thorough external inspection of the engine mount, crankcase, and nose section to determine whether any parts have been damaged. If damage is found which cannot be corrected by line maintenance, remove the engine.

(2) Remove the engine oil screens or filters. Inspect them for the presence of metal particles. Remove the engine sump plugs, drain the oil into a clean container, strain it through a clean cloth, and check the cloth and the strained oil for metal particles. Heavy metal particles in the oil indicate a definite engine failure, and the engine must be removed. However, if the metal particles present are similar to fine filings, continue the inspection of the engine to determine its serviceability.

If there are no heavy metal particles in the engine oil, give the engine a flight test. If the engine operates properly during the flight test, look again for metal in the oil system. If no metal is found, continue the engine in service, but re-check the oil screens for the presence of metal after 10 hours of operation and again after 20 hours of operation. If no indication of internal failure is found after 20 hours of operation, the engine probably requires no further special inspections.

(3) Remove the propeller and check the crankshaft, or the propeller drive shaft on reduction-gear engines, for misalignment. Clamp a test indicator to the nose section of the engine. Use the dial-type reversible indicator which has 1/1000-inch graduations. Remove the front or outside spark plugs from all the cylinders. Then turn the crankshaft and observe if the crankshaft or propeller shaft runs out at either the front or rear propeller cone seat locations.

If there is an excessive runout reading at the crankshaft or propeller-drive shaft at the front seat location, the engine should be removed. Consult the applicable manufacturer's instructions for permissible limits. Even though the runout of the crankshaft or propeller-drive shaft at the front cone seat is less than allowable limits, the rear cone seat location should be checked. If any runout is found at the rear seat location, which is not in the same plane as the runout at the front cone seat location, the engine should be removed.

If the crankshaft or propeller drive shaft runout does not exceed these limits, install a serviceable propeller. Make an additional check by tracking the propeller at the tip in the same plane perpendicular to the axis of rotation to assure that blade track tolerance is within the prescribed limits.

(4) Start the engine to see if operation is smooth and the power output adequate. If the engine operates properly during this ground check, shut the engine down and repeat the inspection for metal particles in the oil system.

Metal Particles in the Oil

Metal particles on the engine oil screens or the magnetic sump plugs are generally an indication of partial internal failure of the engine. However, due to the construction of aircraft oil systems, it is possible that metal particles have collected in the oil system sludge at the time of a previous engine failure. Furthermore, carbon tends to break loose from the interior of the engine in rock-like pieces which have the appearance of metal. It is necessary to consider these possibilities when foreign particles are found on the engine oil screens or sump plugs.

Before removing an engine for suspected internal failure as indicated by foreign material on the oil screens or oil sump plugs, determine if the foreign particles are metal by placing them on a flat metal object and striking them with a hammer. If the material is carbon, it will disintegrate, whereas metal will either remain intact or change shape, depending on its malleability.

If the particles are metal, determine the probable extent of internal damage. For example, if only small particles are found which are similar in nature to filings, drain the oil system, and refill it. Then ground-run the engine and re-inspect the oil screens and sump plugs. If no additional particles are found, the aircraft should be test flown, followed by an inspection of the oil screens and sump plugs. If no further evidence of foreign material is found, continue the engine in service. However, engine performance should be closely observed for any indication of difficulty or internal failure.

Unstable Engine Operation

Engines are usually removed when there is consistent unstable engine operation. Unstable engine operation generally includes one or more of the following conditions:

(1) Excessive engine vibration.
(2) Back firing, either consistent or intermittent.
(3) Cutting-out while in flight.
(4) Low power output.

PREPARATION OF RECIPROCATING ENGINES FOR INSTALLATION

After the decision has been made to remove an engine, the preparation of the replacement engine must be considered. The maintenance procedures and methods used vary widely. Commercial operators, whose maintenance operations require the most efficient and expeditious replacement of aircraft engines, usually rely on a system that utilizes the quick-engine-change assembly, or QECA, also sometimes referred to as the engine power package. The QECA is essentially a powerplant and the necessary accessories installed in the engine mount ring.

Other operators of aircraft equipped with radial engines and most opposed-type engines use a slower but less-expensive method. Since engine replacement in these repair facilities often occurs at random intervals, only a few replacement engines (sometimes only one) are kept on hand. Such replacement engines may be partially or wholly built up with the necessary accessories and subassemblies, or they may be stored as received from the manufacturer in packing boxes, cases, or cans and are uncrated and built up for installation only when needed to replace an engine.

The QECA system is most commonly used with large radial engines, and for this reason such engines are used to describe QECA buildup and installation procedures. But it should be emphasized that many of these procedures are applicable to all other methods of engine buildup and installation.

QECA BUILDUP OF RADIAL ENGINES

The study of QECA buildup that follows is not designed to outline procedures to be followed in a practical application, since most maintenance shops develop buildup procedures tailored to their own facilities or use those recommended by the manufacturer. The procedures included in this chapter provide a logical sequence in following a QECA and its components through the stages of a typical buildup to gain a better understanding of units and systems interconnection.

The components of a QECA for a large radial engine are illustrated in figure 8–1. As shown, the QECA consists of several units. Among such units that are common to most present-day aircraft QECA's are the airscoop, cowl flaps, engine ring cowl, cowl support ring, access panels, engine mount, and the engine, together with all of its accessories and controls.

On many aircraft the engines are mounted in streamlined housings called nacelles that extend from the wings. These nacelles can be considered as being divided into two sections: (1) The wing nacelle, and (2) the engine nacelle. The wing nacelle is that portion of the nacelle which is attached to the wing structure. The engine nacelle is that portion of the nacelle that is constructed separately from the wing.

Figure 8–2 illustrates a typical nacelle with the separation line identified. Outwardly, the wing nacelle seems to be only a streamlining for the engine nacelle, but that is not its only purpose. On many aircraft, the inboard wing nacelle houses the landing gear when it is in the retracted position. Also, the wing nacelles normally contain lines and units of the oil, fuel, and hydraulic systems, as well as linkages and other controls for the operation of the engine.

The point at which the engine nacelle is disconnected from the wing nacelle can easily be identified on most aircraft. To locate the point of disconnect, find the last section of removable engine nacelle cowling farthest from the propeller end of the engine. Normally the removal of these sections of cowling will expose lines, fittings, electrical connections, cables, and mount bolts. The separation point of a QECA, including the firewall and the points of disconnect, is illustrated in figure 8–3.

The firewall is usually the foremost bulkhead of the wing nacelle and differs from most other aircraft bulkheads in that it is constructed of stainless steel or some other fire-resistant material. The primary purpose of the firewall is to confine any engine fire to the engine nacelle. It also provides a mounting surface for units within the engine nacelle and a point of disconnect for lines, linkages, and electrical wiring that are routed between the engine and the aircraft. Without this firewall, an engine fire would have ready access to the interior of the wing. Since the fuel tanks are usually contained in the wings, the probable consequences of an engine fire are obvious. Thus, the necessity for sealing all unused openings in the firewall cannot be overstressed.

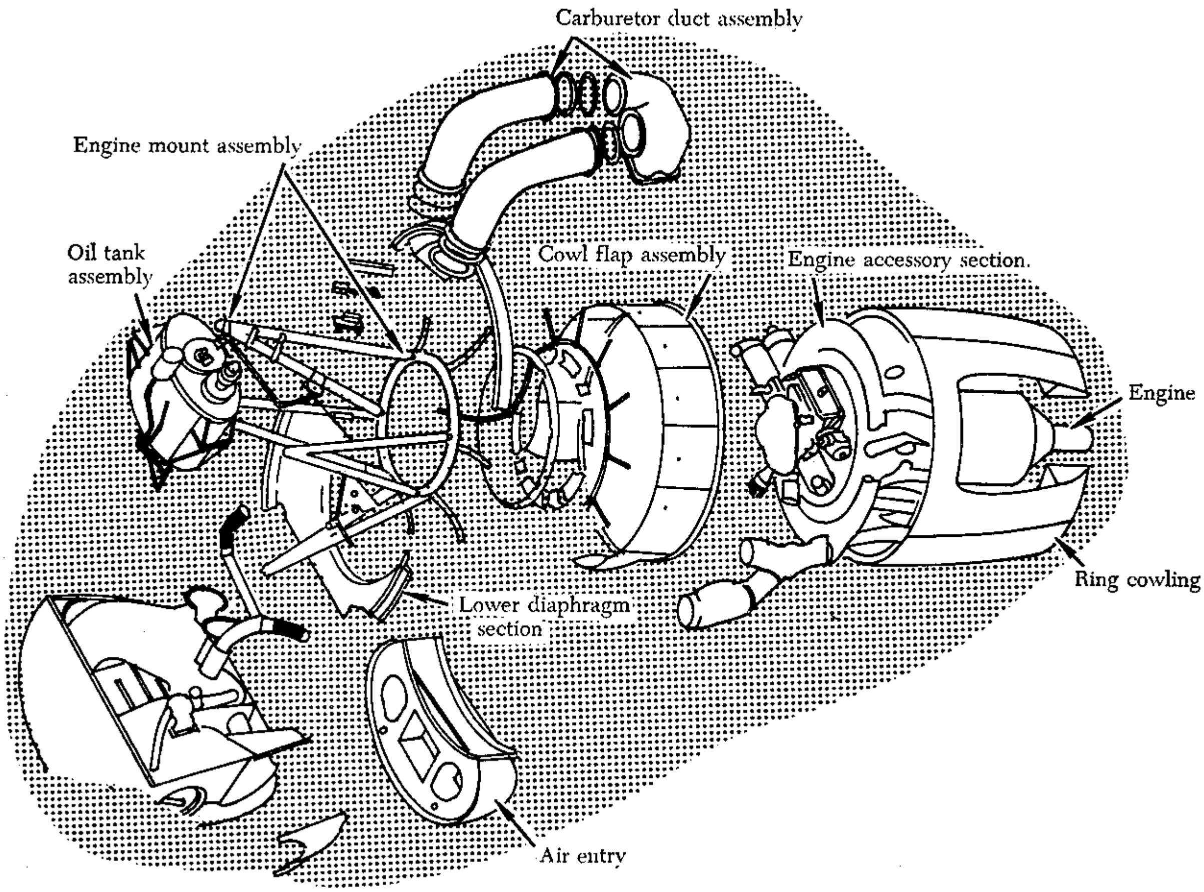


FIGURE 8–1. Exploded view of a typical power package.

An aircraft engine and its accessories which have been in storage must undergo careful de-preservation and inspection before they may be installed in an aircraft. This involves more than removing an engine from its container and bolting it to the aircraft.

If the engine is stored in a pressurized metal container, the air valve should be opened to bleed off the air pressure. Depending upon the size of the valve, the air pressure should bleed off in somewhat less than 30 minutes.

Prepare the container for opening by removing the bolts that hold the two sections together. Then attach a hoist to the "hoisting points" and lift the top section clear of the container and place it away from the work area. If the engine is installed in a wooden shipping case, it is necessary to carefully break the seal of the protective envelope and fold it down around the engine. Remove the dehydrating agent or desiccant bags and the humidity indicator from the outside of the engine. Also, remove and set safely aside any accessories that are not installed on the engine but are mounted on a special stand or otherwise installed inside the protective envelope with the engine. If the engine is a radial type, the mounting ring bolts must be unfastened from the container and the engine hoisted slightly to allow the mounting ring to be removed from the engine. Engines other than radial types are usually bolted directly to the container.

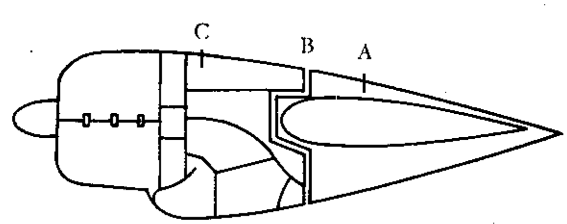
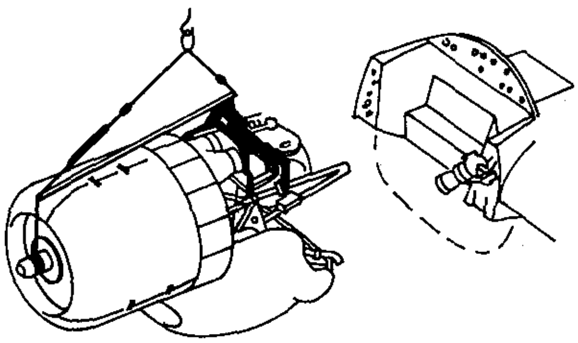
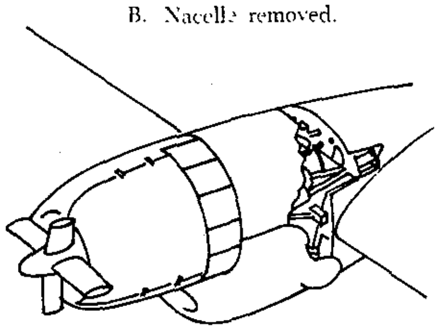


FIGURE 8–2. Typical engine and wing nacelle.



B. Nacelle removed.



A. Nacelle installed.

FIGURE 8–3. Separation line of a typical QECA.

De-preservation of an Engine

After the engine has been secured to an engine stand, all covers must be removed from the points where the engine was sealed or closed with ventilatory covers, such as the engine breathers, exhaust outlets, and accessory mounting-pad cover plates. As each cover is removed, inspect the uncovered part of the engine for signs of corrosion. Also, as the dehydrator plugs are removed from each cylinder, make a very careful check of the walls of any cylinder for which the dehydrator plug color indicates an unsafe condition. Care is emphasized in the inspection of the cylinders, even if it is necessary to remove a cylinder.

On radial engines, the inside of the lower cylinders and intake pipes should be carefully checked for the presence of excessive corrosion-preventive compound that has drained from throughout the interior of the engine and settled at these low points. This excessive compound could cause the engine to become damaged from a hydraulic lock (also referred to as liquid-lock) when a starting attempt is made.

The check for excessive corrosion-preventive compound in the cylinders can be made as the dehydrator plugs are removed from each cylinder. Much of the compound will drain from the spark plug holes of the lower cylinders of a radial engine when the dehydrator plugs are removed. But some of the mixture will remain in the cylinder head below the level of the spark plug hole, as shown in figure 8–4, and can be removed with a hand pump. A more positive method, however, is to remove the lower intake pipes and open the intake valve of the cylinder by rotating the crankshaft. This latter method allows the compound to drain from the cylinder through the open intake valve. If, for some reason, excessive compound is present in an upper cylinder, it can be removed with a hand pump.

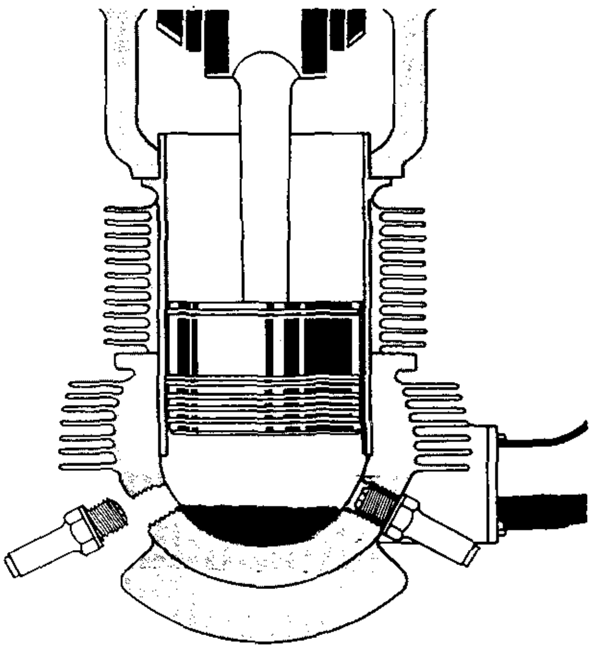


FIGURE 8–4. Draining corrosion-preventive compound.

The oil screens should be removed from the engine and thoroughly washed in kerosene or an approved solvent to remove all accumulations that could restrict the oil circulation and cause engine failure. After the screens are cleaned, immerse them in clean oil and then re-install them in the engine.

When the cover has been removed from the intake manifold, the silica gel desiccant bags must be removed before installing the carburetor. Take care not to accidentally tear one of the bags.

Remove the protective covering from the propeller shaft and wash all corrosion-preventive compound from both the inside and outside surfaces of the shaft. Then coat the propeller shaft lightly with engine oil.

As a final check, see that the exterior of the engine is clean. Usually a quantity of compound runs out of the engine when the dehydrator plugs and oil screens are removed. To clean the engine, spray it with kerosene or an approved commercial solvent.

Inspection and Depreservation of Accessories

An engine's performance is no better than that of its accessories. Though the engine has been completely overhauled and is in top condition, any oversight or error in installing the accessories can result in improper engine operation or even irreparable damage to it.

Before de-preserving any of the accessories enclosed with the engine, consult the storage data usually stenciled on the outside of the engine container or the records enclosed with the engine to determine how long the engine and accessories were in storage. Certain accessories that normally accompany an engine from overhaul are considered unsafe for use if their time in storage has exceeded a specified period. This time varies according to the limits prescribed by the manufacturer.

Any accessory that has been removed from the old engine and can be installed on the new one must be given a thorough inspection to determine its condition. This inspection includes a check for general condition, cleanliness, absence of corrosion, and absence of wear as evidenced by excessive "play" in the moving parts.

Some accessories must be replaced, regardless of their operating time, if the engine is being changed because of internal failure. Such accessories may have been contaminated by metal particles carried into their operating mechanisms by the engine oil that lubricates them.

Before installing any replacement accessory, check it visually for signs of corrosion and for freedom of operation. Always wipe the mounting pad, flange, and coupling clean before mounting the accessory, and install the proper gasket between the mounting pad and the accessory mounting flange. Lubricate the accessory drive shaft when indicated in the manufacturer's instructions.

INSPECTION AND REPLACEMENT OF POWER-PLANT EXTERNAL UNITS AND SYSTEMS

The engine nacelle must be cleaned thoroughly before it is inspected. The design of an engine nacelle varies with different aircraft. Basically, it is a framework, covered with removable cowling, in which the engine is mounted. This assembly is attached to the aircraft and incorporates an insulating firewall between the engine and the airframe. The interconnecting wiring, tubing, and linkages between the engine and its various systems and controls pass through the firewall.

Inspect the complete engine nacelle for condition of the framework and the sheet-metal cowling and riveted plates that cover the nacelle. Any cracks in the cowling or ducts, if they do not exceed limits specified in the manufacturer's structural repair requirements for the aircraft concerned, may be stop-drilled at the end of the crack and repaired by covering the cracked area with a reinforcing patch.

The engine mounting frame assembly should be checked for any distortion of the steel tubing, such as bends, dents, flat spots, or cracks. Use the dye penetrant inspection method to reveal a crack, porous area, or other defects.

The engine mounting bolts are usually checked for condition by magnetic particle inspection or other approved process. While the bolts are removed, the boltholes should be checked for elongation caused by the movement of an improperly tightened bolt.

Check the outer surface of all exposed electrical wiring for breaks, chafing, or other damage. Also, check the security of crimped or soldered cable ends. In addition, carefully inspect connector plugs for overall condition. Any item that is damaged must be repaired or replaced, depending on the extent of the damage.

Before installing an engine, inspect all tubing in the nacelle for dents, nicks, scratches, chafing, or corrosion. Check all tubing carefully for indications of fatigue or excessive flatness caused by improper or accidental bending. Thoroughly inspect all hose used in various engine systems. Weather checking (a cracking of the outside covering of the hose) sometimes penetrates to the hose reinforcement. Replace any length of hose that shows indications of the cover peeling or flaking or whose fabric reinforcement is exposed.

Replace a hose that shows indications of excessive "cold flow." Cold flow is a term used to describe the deep and permanent impressions or cracks caused by hose clamp pressure.

Always replace a control rod if it is nicked or corroded deep enough to affect its strength. If the corrosion cannot be removed by rubbing with steel wool, the pitting is too deep for safety.

Check the pulleys in the control system for freedom of movement. It is easy to spot a pulley that is not turning freely, for both it and the cable will be worn from the cable sliding over the pulley instead of rolling free. The bearings of a pulley may be checked by inspecting the pulley for excessive "play" or "wobble" with the tension removed from the cable. The cable must also be inspected for corrosion and broken strands. Locate any broken strands by wiping the cable with a cloth.

Check bonding for fraying, loose attachment, and cleanness of terminal ends. The electrical resistance of the complete bond must not exceed the resistance values specified in the applicable manufacturer's instructions.

Inspect the exhaust stacks, collector ring, and tailpipe assembly for security, cracks, or excessive corrosion. Depending on the installation, these units or parts of them may be mounted on the engine before it is installed in the aircraft.

Check all air ducts for dents and for the condition of the fabric or rubber anti-chafing strips at the points where sections of duct are joined. The dents may be pounded out; the anti-chafing strips should be replaced if they are pulled loose from the duct or are worn to the point where they no longer form a tight seal at the joint.

Thoroughly inspect the engine oil system and perform any required special maintenance upon it before installing a replacement engine. If an engine is being changed at the end of its normal time in service, it is usually necessary only to flush the oil system; however, if an engine has been removed for internal failure, usually some units of the oil system must be replaced and others thoroughly cleaned and inspected.

If the engine has been removed because of internal failure, the oil tank is generally removed to permit thorough cleaning. Also, the oil cooler and temperature regulator must be removed and sent to a repair facility for overhaul. The vacuum pump pressure line and the oil separator in the vacuum system must also be removed, cleaned, and inspected. Internal failure also requires that the propeller governor and feathering pump mechanism be replaced if these units are operated by engine oil pressure.

PREPARING THE ENGINE FOR REMOVAL

Before starting to work on the aircraft or the engine, always be sure that the magneto switch is in the "OFF" position. Aircraft engines can be started accidentally by turning the propeller, if the magneto switch is on.

Check to see that all fuel selectors or solenoid-operated fuel shutoff valves are closed. The fuel selector valves are either manually or solenoid operated. If solenoid-operated fuel shutoff valves are installed, it may be necessary to turn the battery switch on before the valves can be closed, since the solenoid depends on electricity for operation. These valves close the fuel line at the firewall between the engine and the aircraft. After ensuring that all fuel to the engine is shut off, disconnect the battery to eliminate the possibility of a "hot" wire starting a fire. If it is anticipated that the aircraft will be out of service for more than 6 days, the battery is normally removed and taken to the battery shop and placed on charge.

Also, a few other preparations should be made before starting to work on the engine removal. First, make sure that there are enough fire extinguishers near at hand to meet any possible emergency. Check the seals on these extinguishers to be sure the extinguishers have not been discharged. Then check the wheel chocks. If these are not in place, the aircraft can, and probably will, inch forward or back during some crucial operation. Also, if the aircraft has a tricycle landing gear, be sure that the tail is supported so that the aircraft cannot tip back when the weight of the engine is removed from the forward end. It is not necessary to support the tail on some multi-engine aircraft if only one engine is to be removed. In addition, the landing gear shock struts can be deflated to prevent them from extending as the engine weight is removed from the aircraft.

After taking these necessary precautions, begin removing the cowling from around the engine. As it is removed, clean it and check for cracks so that the necessary repairs can be made while the engine change is in progress. Place all cowling that does not need repair on a rack where it can be readily found when the time comes to re-install it around the new engine.

After removing the cowling, the propeller should be removed for inspection or repair.

Draining the Engine

Place a large metal pan (drip pan) on the floor under the engine to catch any spilled mixture or oil. Next, secure a clean container in which to drain the oil or corrosion-preventive mixture. Place the container beneath the Y drain located between the oil tank and the oil inlet to the engine, open the valve, and allow the oil to drain. Figure 8–5 shows the points at which a typical aircraft engine oil system is drained.

Other points at which the oil system is drained, as shown schematically on a typical engine installation in figure 8–5, include the oil cooler, the oil return line, and the engine sumps. All valves, drains, and lines must remain open until the oil system has been completely drained.

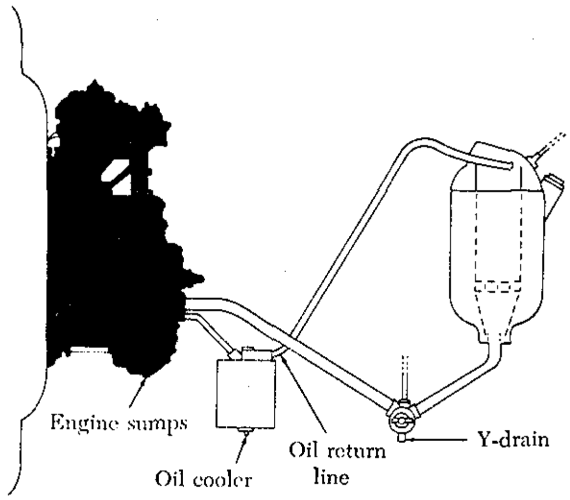


FIGURE 8–5. Oil system drain points.

After draining the oil, re-install all drain plugs and close all drain valves. Then wipe all excess oil from around the drain points.

Electrical Disconnects

Electrical disconnections are usually made at the engine firewall. This does not always apply when the basic engine is being removed, for then the electrical leads to such accessories as the starter and generators are disconnected at the units themselves. When disconnecting electrical leads, it is a good safety habit to disconnect the magnetos first and immediately ground them at some point on the engine or the assembly being removed. Most firewall disconnections of electrical conduit and cable are simplified by use of AN or MS connectors. Each connector consists of two parts: (1) A plug assembly, and (2) a receptacle assembly. To prevent accidental disconnection during airplane operation, the outlet is threaded to permit a knurled sleeve nut to be screwed to the outlet and then fastened with safety wire, if necessary.

A typical plug fitting assembly is shown in figure 8–6. This figure also shows a typical junction box assembly, which is used as a disconnect on some aircraft engine installations. In the junction box the electrical circuit is completed by fastening two leads to a common terminal. The lead which runs from the junction box to engine is disconnected from the terminal, and the conduit is disconnected from the junction box when preparing to remove the engine.

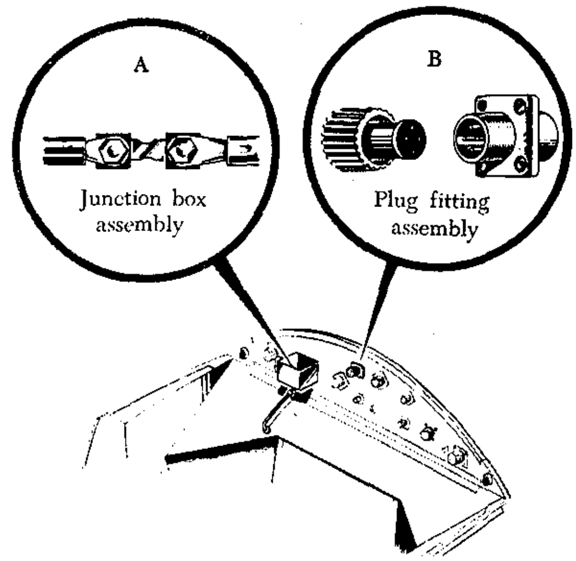


FIGURE 8–6. Plug fitting and junction box assemblies.

After the safety wire is broken, remove all of it from the sleeve nuts which hold the conduit to the junction boxes, as well as from the nuts on the connectors. Wrap moistureproof tape over the exposed ends of connectors to protect them from dirt and moisture. Also, do not leave long electrical cables or conduits hanging loose, since they may become entangled with some part of the aircraft while the engine is being hoisted. It is a good practice to coil all lengths of cable or flexible conduit neatly, and tie or tape them to some portion of the assembly being removed.

Disconnection of Engine Controls

The engine control rods and cables connect such units as the carburetor or fuel control throttle valve and the mixture control valve with their manually actuated control in the cockpit. The controls are sometimes disconnected by removing the turnbuckle which joins the cable ends. A typical assembly is shown in figure 8–7.

Typical control linkage consisting of a control rod attached to a bellcrank is illustrated in figure 8–8.

The control rod in the linkage shown has two rod-end assemblies, a clevis and an eye, screwed onto opposite ends. These rod-end assemblies determine the length of the control rod by the distance

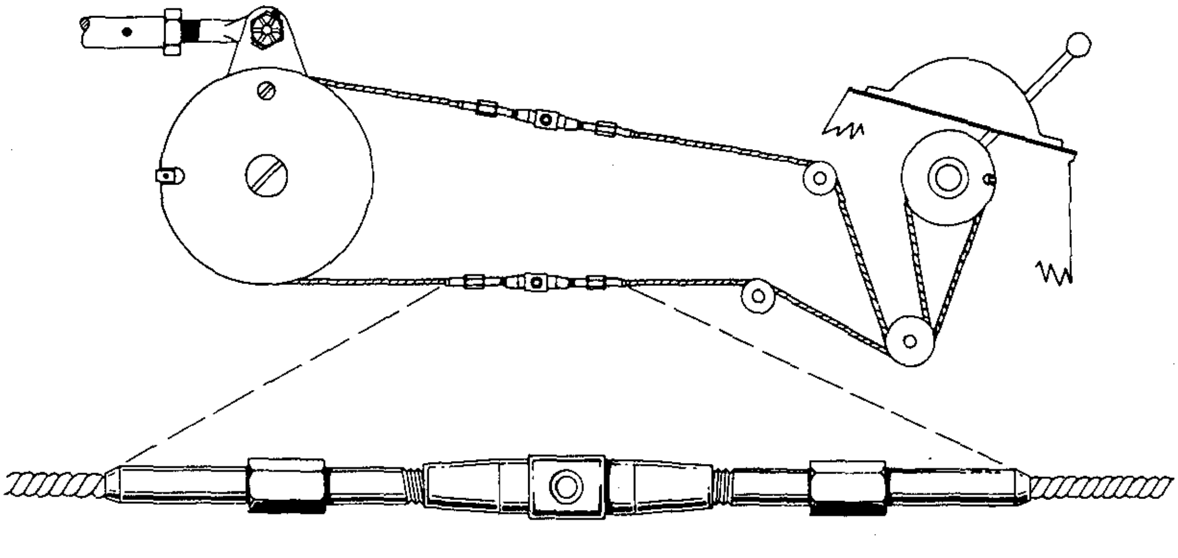


FIGURE 8–7. Engine control cable and turnbuckle assembly.

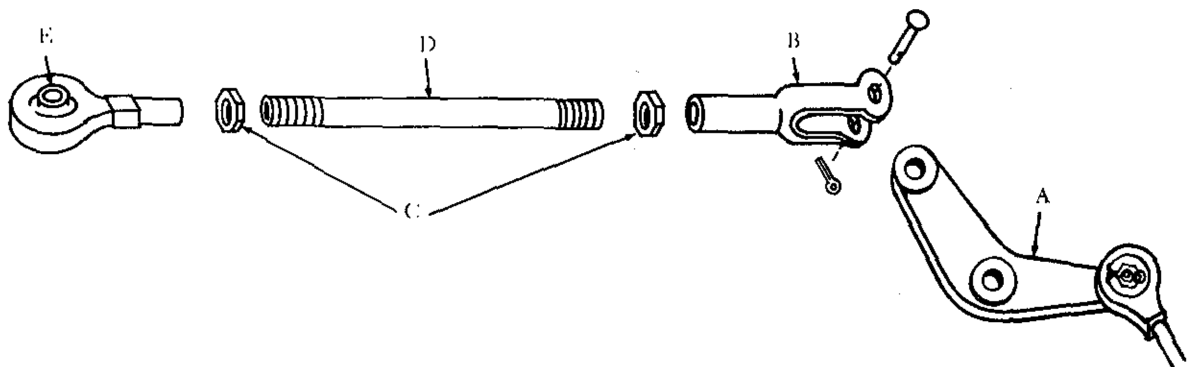
they are screwed onto it, and are locked into position by checknuts. An anti-friction bearing is usually mounted in the eye end of a rod. This eye is slipped over a bolt in the bellcrank arm and is held in position by a castle nut safetied with a cotter pin. The clevis rod end is slipped over the end of a bellcrank arm, which also usually contains an anti-friction bearing. A bolt is passed through the clevis and the bellcrank eye, fastened with a castle nut, and safetied with a cotter pin.

Sometimes linkage assemblies do not include the anti-friction bearings and are held in position only by a washer and cotter pin in the end of a clevis pin which passes through the bellcrank and rod end. After the engine control linkages have been disconnected, the nuts and bolts should be replaced in the rod ends or bellcrank arms to prevent their being lost. All control rods should be removed completely or tied back to prevent them from being bent or broken if they are struck by the replacement engine or QECA as it is being hoisted.

Disconnection of Lines

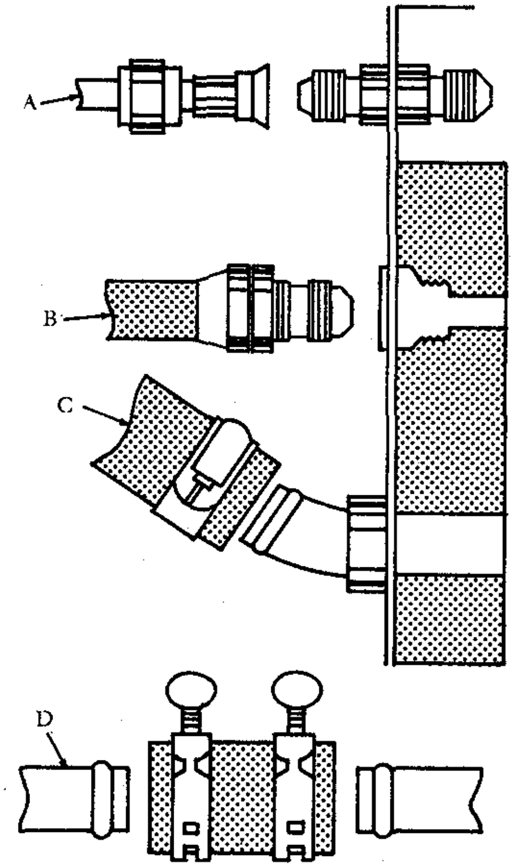
The lines between units within the aircraft and the engine are either flexible rubber hose or aluminum-alloy tubes joined by lengths of hose clamped to them. Lines which must withstand high pressure, such as hydraulic lines, are often stainless steel tubing.

Figure 8–9 shows the basic types of line disconnects. Most lines leading from a QECA are secured to a threaded fitting at the firewall by a sleeve nut around the tubing. Hoses are sometimes secured in this manner but may also be secured by a threaded fitting on the unit to which they lead, or by a hose clamp. The firewall fittings for some lines have a quick-disconnect fitting that contains a check valve



A. Bellcrank B. Clevis C. Checknuts D. Control rod E. Eye

FIGURE 8–8. Engine control linkage assembly.



A. Sleeve and nut fitting

B. Threaded fitting and receptacle

C. Hose clamp and fitting

D. Interconnecting hose

FIGURE 8–9. Types of line disconnects.

to prevent the system from losing fluid, when the line is disconnected. Metal tubing on some installations may also be disconnected at a point where two lengths of it are joined together by a length of rubber hose. Such a disconnection is made by loosening the hose clamps and sliding the length of rubber hose over the length of tubing which remains on the aircraft. There may be some further variations in these types of disconnections, but basically they follow the same pattern.

Some type of a container should be used to catch any fuel, oil, or other fluid that may drain from the disconnected lines. After the lines have drained, they should be immediately plugged or covered with moistureproof tape to prevent foreign matter from entering them as well as to prevent any accumulated fluid from dripping out.

Other Disconnections

The points at which the various air ducts are disconnected depend upon the engine and the aircraft in which it is installed. Usually the air intake ducts and the exhaust system must be disconnected so the basic engine or the QECA can be removed. After the engine connections are free (except the engine mounts) and all the disconnections are entirely clear so they will not bind or become entangled, the engine can be prepared for hoisting.

REMOVING THE ENGINE

If there has been thorough preparation of the engine for removal, the actual removal should be a relatively speedy operation.

If a QECA is being removed, the engine mount will accompany the engine; but if only the engine is being removed, the mount will remain on the aircraft. Before the engine can be freed from its attachment points, a sling must be installed so the engine's weight can be supported with a hoist when the mounting bolts are removed.

Aircraft engines or QECA's have marked points for attaching a hoisting sling. The location of these attaching points varies according to the size and weight distribution of the engine. Figure 8–10 shows a sling supporting an engine which has two attaching points. As a matter of safety, the sling should be carefully inspected for condition before installing it on the engine.

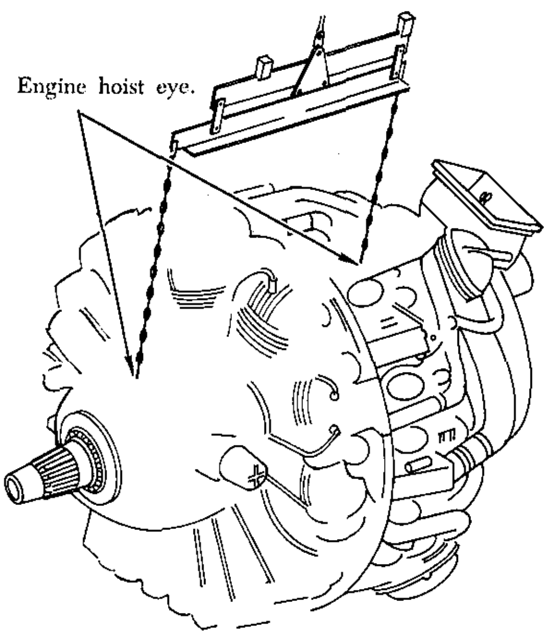


FIGURE 8–10. Engine showing hoisting sling attached.

Before attaching the sling to the hoist, be sure that the hoist has sufficient capacity to lift the engine safely. A manually operated hoist mounted in a portable frame is shown in figure 8–11. This hoist assembly is specifically manufactured for the purpose of removing engines and other large assemblies from aircraft. Some frames are fitted with power-operated hoists. These should be used with care, since considerable damage can be done if an inexperienced operator allows a power-operated hoist to overrun. The hoist and frame should also be checked for condition before being used to lift the engine.

Hoisting the Engine

Before the hoist is hooked onto the engine sling, re-check the aircraft tail supports and the wheel chocks. Fasten lines to the engine at points on the sides or rear so that the engine can be controlled as it is being hoisted. Hook the hoist onto the sling and hoist the engine slightly — just enough to relieve the engine weight from the mount attachments. Remove the nuts from the mount attachments in the order recommended in the manufacturer's instructions for the aircraft. As the last nuts are being removed, pull back on the lines fastened to the engine (or force it back by other means if lines are not being used), thus steadying the engine. If bolts must be removed from the mount attachments, be sure the engine is under control before doing so. If the bolts are to remain in the mount attachments, the hoist can be gently maneuvered upward or downward as necessary after all the nuts have been removed. Meanwhile, gently relax the backward force on the engine just enough to allow the engine gradual forward movement when it is free from the mount attachments. At the point where the hoist has removed all engine weight from the mount attachments, the engine should be eased gently forward, away from the aircraft. If the engine binds at any point, maneuver it with the hoist until it slips free.

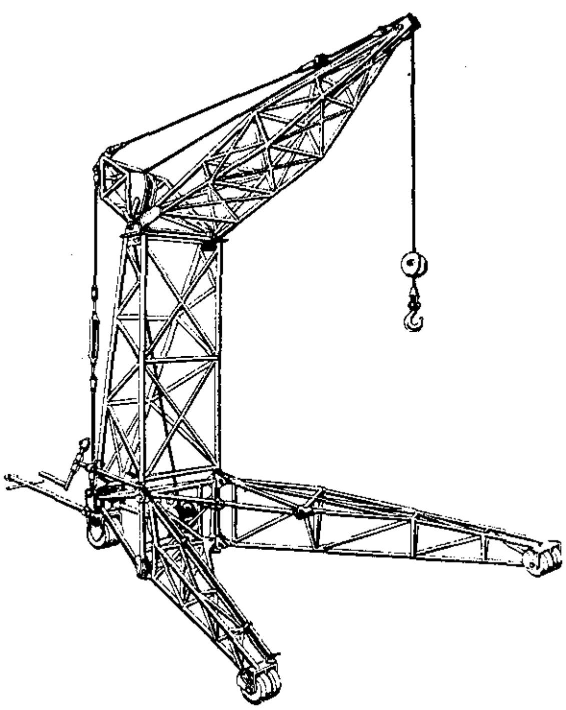


FIGURE 8–11. Hoist and frame assembly used for engine removal.

The procedure just discussed applies to removal of most reciprocating and turbine aircraft engines. Any variation in details will be outlined in the manufacturer's instructions for the aircraft concerned. Before attempting any engine removal, always consult these instructions.

When the engine has been removed, it can be carefully lowered onto a stand. The engine should be fastened to the stand and prepared for the removal of accessories.

HOISTING AND MOUNTING THE ENGINE FOR INSTALLATION

When the new or overhauled engine is ready to be hoisted for installation, move the engine stand as close as possible to the nacelle in which the replacement is to be installed. Then attach the sling to the engine and hook the hoist to the sling; then take up the slack until the hoist is supporting most of the engine weight. Next, remove the engine attaching bolts from the stand and hoist the engine clear.

The engine stand may be moved and the hoist frame positioned in a way that most easily permits the engine to be hoisted into the nacelle. To prevent injury to the crew or damage to the aircraft or engine, be sure that the engine is steadied when moving the hoist frame.

Seldom is an engine nacelle so designed that the engine can be fitted and bolted into place as though it were being mounted on a bare wall. The engine must be guided into position and mated with its various connections, such as the mounting boltholes and the exhaust tailpipe. This must be done despite such obstacles as the nacelle framework, ducts, or firewall connections and without leaving a trail of broken and bent parts, scratched paint, or crushed fingers.

When the engine has been aligned correctly in the nacelle, insert the mounting bolts into their holes and start all of the nuts on them. Always use the type of bolt and nut recommended by the manufacturer. Never use an unauthorized substitution of a different type or specification of nut and bolt than that prescribed.

The nuts on the engine mount bolts must be tightened to the torque recommended by the aircraft manufacturer. While the nuts are being tightened, the hoist should support the engine weight sufficiently to allow alignment of the mounting bolts. If the engine is permitted to exert upward or downward pressure on the bolts, it will be necessary for the nuts to pull the engine into proper alignment. This will result in nuts being tightened to the proper torque value without actually holding the engine securely to the aircraft.

The applicable manufacturer's instructions outline the sequence for tightening the mounting bolts to ensure security of fastening. After the nuts are safetied and the engine sling and hoist are removed, bonding strips should be connected across each engine mount to provide an electrical path from the mount to the airframe.

Mounting the engine in the nacelle is, of course, only the beginning. All the ducts, electrical leads, controls, tubes, and conduits must be connected before the engine can be operated.

Connections and Adjustments

There are no hard and fast rules that direct the order in which units or systems should be connected to the engine. Each maintenance organization will normally supply a worksheet or checklist to be followed during this procedure. This list is based upon past experience in engine installation on each particular aircraft. If this is followed carefully, it will serve as a guide for an efficient installation. The following instructions, then, are not a sequence of procedures but are a discussion of correct methods for completing an engine installation.

The system of ducts for routing air to the engine varies with all types of aircraft. In connecting them, the goal is to fit the ducts closely at all points of disconnect so that the air they route will not escape from its intended path. The duct systems of some aircraft must be pressure-checked for leaks. This is done by blocking the system at one end, supplying compressed air at a specified pressure at the other end, and then checking the rate of leakage.

The filters in the air induction system must be cleaned to assure an unrestricted flow of clean air to the engine and its units. Because methods for cleaning air filters vary with the materials used in the filtering element, clean them in accordance with the technical instructions relating to the aircraft being serviced.

The exhaust system should also be carefully connected to prevent the escape of hot gases into the nacelle. When assembling the exhaust system, check all clamps, nuts, and bolts and replace any in doubtful condition. During assembly, the nuts should be gradually and progressively tightened to the correct torque. The clamps should be tapped with a rawhide mallet as they are being tightened to prevent binding at any point. On some systems a ball joint connects the stationary portion of the exhaust system to the portion that is attached to the engine. This ball joint absorbs the normal engine movement caused by the unbalanced forces of the engine operation. Ball joints must be installed with the specified clearance to prevent binding when expanded by hot exhaust gases.

Hoses used within low-pressure systems are generally fastened into place with clamps. Before using a hose clamp, inspect it for security of welding or riveting and for smooth operation of the adjusting screw. A clamp that is badly distorted or materially defective should be rejected. (Material defects include extremely brittle or soft areas that may easily break or stretch when the clamp is tightened.) After a hose is installed in a system, it should be supported with rubber-lined supporting clamps at regular intervals.

Before installing metal tubing with threaded fittings, make sure the threads are clean and in good condition. Apply sealing compound, of the correct specification for the system, to the threads of the fittings before installing them. While connecting metal tubing, follow the same careful procedure for connecting hose fittings to prevent cross-threading and to assure correct torque.

When connecting the leads to the starter, generator, or various other electrical units within the nacelle, make sure that all connections are clean and properly secured. On leads that are fastened to a threaded terminal with a nut, a lockwasher is usually inserted under the nut to prevent the lead from working loose. When required, connector plugs can be safetied with steel wire to hold the knurled nut in the "full-tight" position.

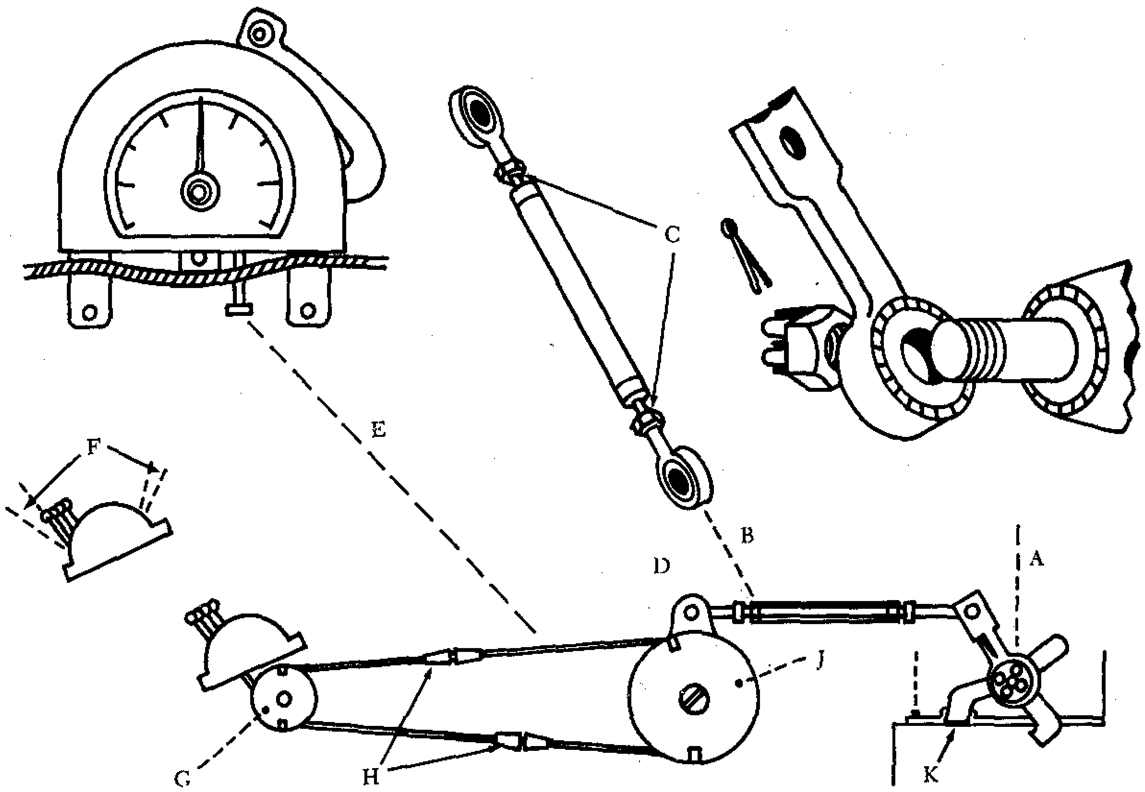
Electrical leads within the engine nacelle are usually passed through either a flexible or a rigid conduit. The conduit must be anchored as necessary to provide a secure installation, and bonded when required.

All engine controls must be accurately adjusted to assure instantaneous response to the control setting. For flexibility, the engine controls are usually a combination of rods and cables. Since these controls are tailored to the model of aircraft in which they are installed, their adjustment must follow exactly the step-by-step procedure outlined in the manufacturer's instructions for each particular model of aircraft.

Figure 8–12 illustrates a simplified schematic drawing of a throttle control system for a reciprocating aircraft engine. Using the drawing as a guide, follow a general procedure for adjusting throttle controls. First, loosen the serrated throttle control arm at the carburetor and back off the throttle stop until the throttle valve is in the "fully closed" position. After locking the cable drum into position with the locking pin, adjust the control rod to a specified length. Then, attach one end of the control rod to the locked cable drum and re-install the throttle control arm on the carburetor in the serrations that will allow the other end of the control rod to be attached to it. This will correctly connect the control arm to the cable drum.

Now, loosen the cable turnbuckles until the throttle control can be locked at the quadrant with the locking pin. Then, with both locking pins in place, adjust the cables to the correct tension as measured with a tensiometer. Remove the locking pins from the cable drum and quadrant.

Next, adjust the throttle control so that it will have a slight cushion action at two positions on the



A. Serrated throttle control arm
B. Control rod
C. Adjustable rod ends
D. Cable drum
E. Tensiometer
F. Cushion movement
G. Quadrant locking pin
H. Cable turnbuckle
J. Cable drum locking pin
K. Throttle stop

FIGURE 8–12. Schematic drawing of throttle control system.

throttle quadrant: One when the carburetor throttle valve is in the "full-open" position, and the other when it is closed to the "idle" position.

Adjust the cushion by turning the cable turnbuckles equally in opposite directions until the throttle control cushion is correct at the "full-open" position of the throttle valve. Then, when the throttle arm stop is adjusted to the correct "idle speed" setting, the amount of cushion should be within tolerance at the "idle speed" position of the throttle valve. The presence of this cushion assures that the travel of the throttle valve is not limited by the stops on the throttle control quadrant, but that they are opening fully and closing to the correct idle speed as determined by the throttle arm stop.

Adjustment of the engine controls is basically the same on all aircraft insofar as the linkage is adjusted to a predetermined length for a specific setting of the unit to be controlled. Then, if cables are used in the control system, they are adjusted to a specific tension with the control system locked. Finally, the full travel of the unit to be controlled is assured by establishing the correct cushion in the controls.

In general, the same basic procedure is used to connect the linkage of the manual mixture control. This system is marked at the quadrant and at the carburetor for the three mixture positions: (1) Idle cutoff, (2) auto lean, and (3) auto rich. The positions of the lever on the control quadrant must be synchronized with the positions of the manual mixture control valve on the carburetor. Generally, this adjustment is made simultaneously with the cushion adjustment by placing the mixture control lever and the mixture control valve in the "idle cutoff" position before adjusting the linkage.

After rigging the engine controls, safety the turnbuckles and castle nuts, and make certain the jam nuts on all control rods are tightened.

On multi-engine aircraft the amount of cushion of all throttle and mixture controls on each quadrant must be equal so that all will be aligned at any specific setting chosen. This eliminates the necessity of individually setting each control to synchronize engine operations.

After the engine has been installed, it is necessary to adjust the cowl flaps so that the passage of the cooling air over the engine can be regulated accurately. When the cowl flap adjustments have been completed, operate the system and re-check for opening and closing to the specified limits. Also check the cowl flap position indicators, if installed, to assure that they indicate the true position of the flaps.

The oil cooler doors are adjusted in a manner similar to that used to adjust the cowl flaps. In some cases the procedure is reversed insofar as the door is first adjusted to retract to a specified point and the limit switch on the motor is set to cut out at this point. Then the jackscrew is adjusted to permit the door to open only a specified distance, and the open limit switch is set to stop the motor when this point is reached.

After the engine has been completely installed and connected, install the propeller on the aircraft. Before doing so, the thrust bearing retaining nut should be checked for correct torque. If required, the propeller shaft must be coated with light engine oil before the propeller is installed; the propeller governor and anti-icing system must be connected according to applicable manufacturer's instructions.

PREPARATION OF ENGINE FOR GROUND AND FLIGHT TESTING

Pre-oiling

Before the new engine is flight-tested, it must undergo a thorough ground check. Before this ground check can be made, several operations are usually performed on the engine.

To prevent failure of the engine bearings during the initial start, the engine should be pre-oiled. When an engine has been idle for an extended period of time, its internal bearing surfaces are likely to become dry at points where the corrosion-preventive mixture has dried out or drained away from the bearings. Hence, it is necessary to force oil throughout the entire engine oil system. If the bearings are dry when the engine is started, the friction at high r.p.m. will destroy the bearings before lubricating oil from the engine-driven oil pump can reach them.

There are several methods of pre-oiling an engine. The method selected should provide an expeditious and adequate pre-oiling service. Before using any pre-oiling method, remove one spark plug from each cylinder to allow the engine to be turned over more easily with the starter. Also, connect an external source of electrical power (auxiliary power unit) to the aircraft electrical system to prevent an excessive drain on the aircraft battery. If the engine is equipped with a hydromatic (oil-operated) propeller, remove the plug and fill the propeller dome with oil. Then re-install the plug.

In using some types of pre-oilers, such as that shown in figure 8–13, the oil line from the inlet side of the engine-driven oil pump must be disconnected to permit the pre-oiler tank to be connected at this point. Then a line must be disconnected or an opening made in the oil system at the nose of the engine to allow oil to flow out of the engine. Oil flowing out of the engine indicates the completion of the pre-oiling operation, since the oil has now passed through the entire system.

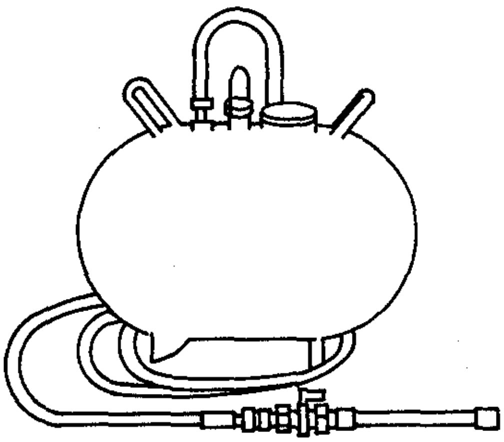


FIGURE 8–13. Pre-oiler tank.

In order to force oil from the pre-oiler tank through the engine, apply air pressure to the oil in the tank while the engine is being turned through with the starter. When this action has forced oil through the disconnection at the nose of the engine, stop cranking the engine and disconnect the pre-oiler tank.

When no external means of pre-oiling an engine are available, the engine oil pump may be used. Fill the engine oil tank to the proper level. Then, with the mixture in the "idle cutoff" position, the fuel shutoff valve and ignition switches in the "off" position, and the throttles fully open, crank the engine with the starter until the oil pressure gage mounted on the instrument panel indicates oil pressure.

After the engine has been pre-oiled, replace the spark plugs and connect the oil system. Generally, the engine should be operated within 4 hours after it has been pre-oiled; otherwise, the pre-oiling procedure normally must be repeated.

Fuel System Bleeding

To purge the fuel system of air locks and to aid in flushing any traces of preservative oil from a pressure carburetor, remove the drain plug in the carburetor fuel chamber which is farthest from the fuel inlet to the carburetor. In its place, screw a threaded fitting to which a length of hose, leading to a suitable container, is attached. Then open the throttle and place the mixture control in the "auto-lean" or "auto-rich" position, so that fuel will be permitted to flow through the system.

After making sure the fuel shutoff and main fuel tank valves are open, turn on the fuel boost pump until there are no traces of preservative oil in the fuel being pumped through the system. The passage of air will be indicated by an audible "blurp" emerging from the end of the hose submerged in the container of fuel. This phenomenon is not to be confused with the numerous small air bubbles that may appear as a result of the velocity of the fuel being ejected from the carburetor. Usually, after approximately a gallon of fuel has been bled off, the system can be considered safe for operation.

After completing the bleeding operation, return all switches and controls to their "normal" or "off" position, and replace and safety the drainplug in the carburetor.

PROPELLER CHECK

The propeller installed on the engine must be checked before, during, and after the engine has been ground operated.

A propeller whose pitch-changing mechanism is electrically actuated may be checked before the engine is operated. This is done by connecting an external source of electrical power to the aircraft electrical system, holding the propeller selector switch in the "decrease r.p.m." position, and checking for an increase of the propeller blade angle. Continue the check by holding the switch in the "increase r.p.m." position and examining the propeller blades for a decrease in angle. The propellers can also be checked for feathering by holding the selector switch in the "feather" position until the blade angle increases to the "full-feather" position. Then return the propeller to a "normal operating" position by holding the switch in the "increase r.p.m." position.

Propellers whose pitch-changing mechanisms are oil actuated must be checked during engine operation after the normal operating oil temperature has been reached. In addition to checking the increase or decrease in r.p.m., the feathering cycle of the propeller should also be checked.

When an engine equipped with an oil-operated propeller is stopped with the propeller in the "feather" position, never unfeather the propeller by starting the engine and actuating the feathering mechanism. Remove the engine sump plugs to drain the oil returned from the feathering mechanism and turn the blades to their normal position using the feathering pump; or a blade wrench, a long-handled device that slips over the blade to permit returning the blades to "normal pitch" position manually, can be used.

CHECKS AND ADJUSTMENTS AFTER ENGINE RUN-UP AND OPERATION

After the engine has been ground-operated, and again after flight test, operational factors must be adjusted, as necessary, and the entire installation given a thorough visual inspection. These adjustments often include fuel pressure and oil pressure, as well as re-checks of such factors as ignition timing, valve clearances, and idle speed and mixture, if these re-checks are indicated by the manner in which the engine performs.

After both the initial ground run-up and the test flight, remove the oil sump plugs and screens and inspect for metal particles. Clean the screens before re-installing them.

Check all lines for leakage and security of attachment. Especially, check the oil system hose clamps for security as evidenced by oil leakage at the hose connections. Also, inspect the cylinder holddown nuts or capscrews for security and safetying. This check should also be performed after the flight immediately succeeding the test flight.

REMOVAL AND INSTALLATION OF AN OPPOSED-TYPE ENGINE

The general information relating to the removal, buildup, inspection, preservation, storage, and installation of radial engines is in most instances applicable to horizontally opposed aircraft engines.

Although many detailed procedures for radial engines are applicable to horizontally opposed engines, they are sometimes unnecessary in practical application.

For example, elaborate and costly hoisting equipment is seldom necessary for removing or installing opposed-type engines, especially for very low horsepower engines. The storage of engines provides another example, since many small engines may be stored or shipped in skid-mounted containers fabricated from heavy-duty cardboard.

Finally, the number of accessories, together with the fewer number of engine controls, electrical and hydraulic lines and connections, and the increased ease of accessiblity to all parts of the engine generally preclude extensive use of QECA.

Engine Removal

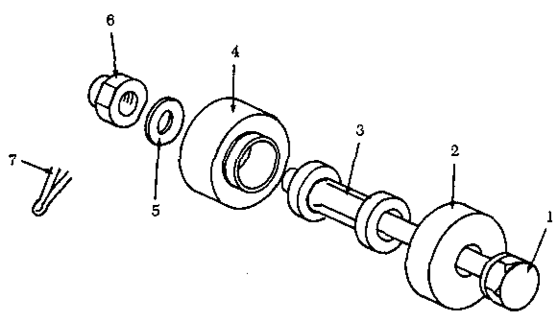
The manufacturer's instructions should always be consulted as a guide in engine removal or installation. The following instructions for a 250 hp. horizontally opposed engine are typical engine removal and installation procedures:

(1) Remove the propeller.
(2) Release the quarter-turn cowl fasteners holding each side-access panel to the cowling, and remove the panels.
(3) Release the cowl fasteners holding the carburetor airscoop cover fairing and remove the fairing. Release the fasteners attaching the cowling to the carburetor air intake bellows.
(4) Remove the screws at the rear of the top and bottom nacelle cowling assembly and remove the cowling.
(5) Disconnect engine oil cooler air duct bellows.
(6) Disconnect primer line.
(7) Disconnect the mechanical fuel pump inlet line.
(8) Disconnect the generator and starter leads.
(9) If installed, remove the cylinder head temperature thermocouple.
(10) Disconnect the oil pressure and manifold pressure lines.
(11) Disconnect the oil return line.
(12) Remove the bonding strap from the rear of the engine.
(13) Disconnect the governor control cable from the governor.
(14) Disconnect the tachometer cable from the rear of the engine.
(15) Disconnect engine oil cooler hoses.
(16) Disconnect the engine oil temperature lead.
(17) Disconnect the engine breather line.
(18) Remove the four carburetor mounting nuts and allow the carburetor and carburetor air box to hang by means of the attached engine controls.
(19) Attach a hoist to the engine-lifting eye and relieve the tension on the mounts.
(20) Disconnect magneto P-leads.
(21) Remove the cotter pin, nuts, washer, and front rubber mount from each bolt and remove the sleeve. Slide bolts out of attaching points. Swing engine free, being careful not to damage any attached parts, and remove rear rubber mounts.

ENGINE INSTALLATION

The following procedures are typical of those used for installing a horizontally opposed engine after the accessories are mounted on the engine:

(1) Insert engine mounting bolts into the engine mount and slide the shock mounts onto the bolts so that the flat surface of the shock mount is flush with the engine mounting pad (see figure 8–14).



1. Engine mounting bolt
2. Shock mount
3. Shock mount spacer
4. Shock mount
5. Washer
6. Castellated nut
7. Cotter pin

FIGURE 8–14. Lord mount, exploded view.

(2) Slide the shock mount spacers onto the engine mounting bolts.

(3) Attach a hoist to the lifting eye and lift the engine. Tilt the rear of the engine downward until the magnetos clear the engine mount. Position the mounting lugs of the engine so that they align with the engine mount attaching points.

(4) Insert an upper mounting bolt into the engine until its threaded end extends one or two threads from the mount itself.

(5) Slide a shock mount between the engine mount and the engine.

(6) Repeat the procedure described in steps (5) and (6), above, for the remaining attachment points.

(7) Install the front engine rubber mounts on the bolts and over the forward end of the sleeve; check to see that shock mounts are not binding.

(8) Insert the magneto P-leads, tighten and safety.

(9) Install a washer and castellated nut on each mounting bolt. Tighten the nuts progressively, following a circular sequence, to the torque value specified by the manufacturer. Install cotter pins.

(10) Install gasket and carburetor air box.

(11) Connect the engine breather line.

(12) Connect the engine oil cooler air duct boot.

(13) Connect the engine oil temperature lead.

(14) Connect the oil cooler hoses.

(15) Connect the tachometer cable.

(16) Attach the propeller governor control cable.

(17) Connect the bonding strap to the engine mount ring.

(18) Connect the oil pressure line.

(19) Re-connect the starter and generator leads.

(20) Install the cylinder head temperature thermocouple.

(21) Connect the primer line.

(22) Re-connect the lines to the vacuum pump.

(23) Re-connect the hydraulic pump lines.

(24) Attach the generator blast tube.

(25) Slide the complete cowl assembly in position and attach the top and bottom sections.

(26) Fasten the quarter-turn fasteners attaching the cowling to the carburetor air intake bellows.

(27) Attach the carburetor airscoop cover fairing.

(28) Install the access panels to each side of the engine by using the quarter-turn cowl fasteners.

(29) Install the propeller.

TURBOJET POWERPLANT REMOVAL AND INSTALLATION

The aircraft engine used in this discussion provides a typical example of turbojet powerplant removal and installation procedures. The engine and all engine-mounted accessories form a QECA.

Access to the engine is provided by doors that can be raised and locked open. Directional references, such as right and left, and clockwise and counterclockwise, apply to the engine as viewed from the aft or exhaust end of the engine.

Turbojet Powerplant QECA Removal

The powerplant may be removed from the aircraft by either of two methods. One method involves lowering the powerplant from the nacelle by using an engine dolly. The other method requires hoists and a special sling to lower the powerplant to a movable engine stand. The following preliminary steps are applicable to either method of removal:

(1) Adequately secure the aircraft either with wheel chocks or with tiedown provisions; attach ground wire or cable to aircraft.

(2) Open the nacelle doors and support them with the struts. Verify that no external power is connected to the aircraft and that the electric power switch is off.
(3) Remove the mount access plates from both sides of the nacelle structure.
(4) Remove the engine air-conditioning duct access plate, and disconnect the duct from the engine.
(5) Disconnect the turbine discharge pressure pickup line (figure 8–15).

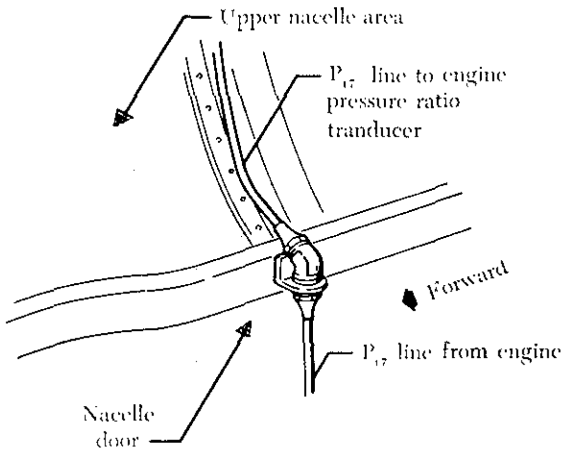


FIGURE 8–15. Turbine discharge pressure (P_{t7}) pickup.

(6) Disconnect the electrical wiring and the thermocouple leads from the connectors (figure 8–16).
(7) Disconnect the fuel line by removing the bolts from the hose flange (figure 8–17).
(8) Disconnect the power control rod (figure 8–18) from the power control lever cross-shaft linkage at the threaded end disconnect. Secure the power control rod to the nacelle structure.

After the engine has been disconnected, except for the engine mounts, and a dolly is being used to remove the engine, position it under the engine. Attach it to the engine and raise the dolly until all the weight is relieved from the wing. If hoists are used connect the hoists to the engine mounts through the accesses on the pylon. When lowering the engine with hoists, operate them simultaneously to exert tension on the hoist cables at all times. Position a movable engine stand under the engine, before lowering it.

With either the hoists or dolly attached and the stand in place, the engine is now ready to be lowered.

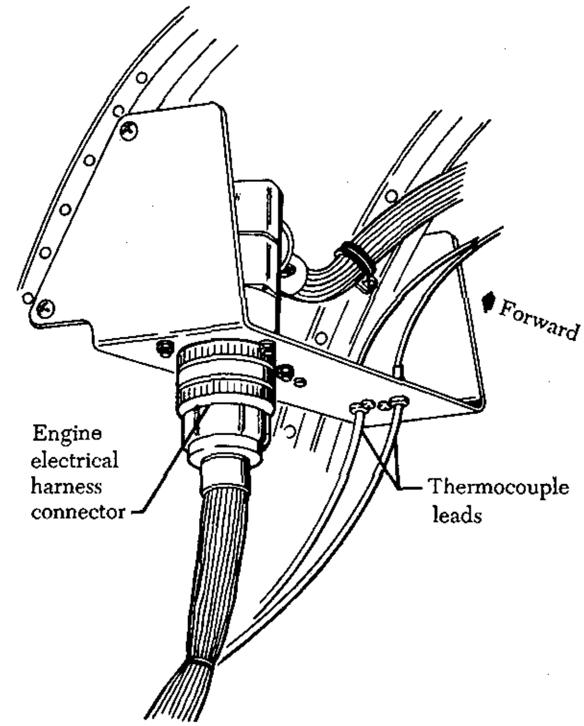


FIGURE 8–16. Electrical disconnect.

Remove the rear engine mount bolt and bushing, and the front engine mount nuts and washers. Start lowering the engine, constantly observing the engine clearance with the nacelle to prevent damage to the engine or to the nacelle. Secure the engine to the dolly or stand. If hoists are used, detach them from the engine. Roll the engine clear of the aircraft. Care must be taken while moving the engine clear to prevent damage to the pylon or pod. Cap or plug all lines, hoses, and outlets. With the engine removed, inspect the power control rod

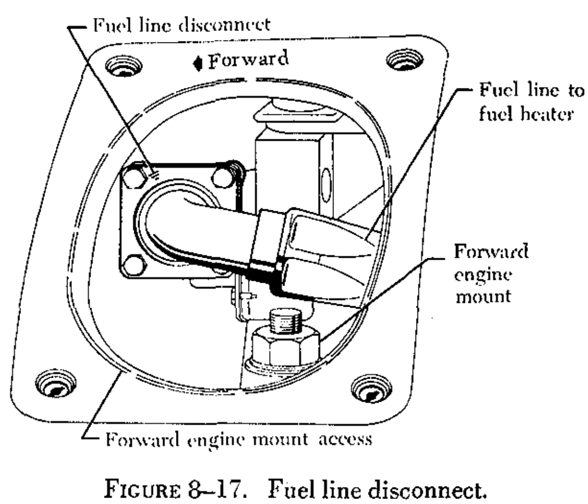


FIGURE 8–17. Fuel line disconnect.

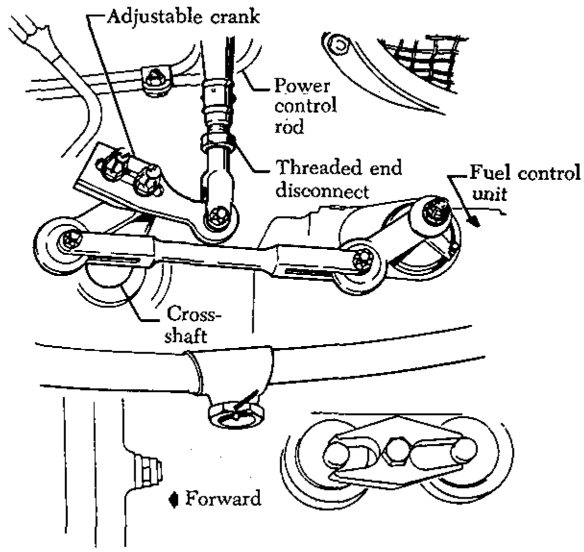


FIGURE 8–18. Power lever disconnect.

bracket and crank assembly for bearing looseness and the nacelle area for structural damage. Inspect for cracks or openings in the area where the pylon structure joins the nacelle structure.

Removal of QECA Accessories

When an aircraft engine is to be replaced, the aircraft-furnished accessories and equipment may be removed either for installation on the replacement engine or for overhaul, as required. Note carefully the locations and attachments of all units before removal so as to aid in the assembly of the replacement powerplant. When accessories are to be sent to overhaul or storage, preserve them in accordance with the manufacturer's instructions and be sure to attach all pertinent data and the proper accessory record cards.

After removal of these accessories and equipment, cover all exposed drives and ports. Prepare the engine for shipment, storage, or disassembly as directed in applicable manufacturer's instructions.

INSTALLATION OF TURBOJET ENGINES

Installation with Dolly

The following procedures are typical of those used to install a turbojet engine using a dolly. Specific ground-handling instructions are normally placarded on the dolly.

(1) Operate the dolly and carefully raise the engine to the engine mount attaching fittings.
(2) Align the rear engine mount with the mount attaching fittings.
(3) Install the engine mount bolts and tighten to the specified torque.

Installation with Hoist

The following procedures are typical of those used to install a turbojet engine using a hoist:

(1) Position the powerplant beneath the nacelle.
(2) Attach the engine sling to the engine.
(3) Carefully operate all the hoists simultaneously to raise the engine and guide the mounts into position.

Installation with Two-Cable Hoist

Figure 8–19 shows an engine being installed using a two-cable hoist. Hoists of this type are commonly used to install medium or small turbojet engines.

Completing the Installation

The following procedures cover the typical final installation instructions:

(1) Install the bushing through the engine rear mount and the rear mount attaching fitting. Install the bolt through the bushing; install the nut and secure it with a cotter pin. On this particular installation the engine rear mount must be free to rotate in the mount fitting. Do not overtighten the mount bolt.
(2) Through the forward mount accesses, place the chamfered washer, flat washer, and nut on each engine forward mount bolt. Tighten the nut to the required torque. Then secure the nut with lockwire.
(3) Connect the air-conditioning duct from the pylon to the compressor bleed-air duct from the engine. Tighten the duct connection by applying the proper torque.
(4) Remove the dolly or slings and related equipment from the engine.
(5) Connect the fuel hose to the fuel line from the pylon. Use a new gasket between the flanges of the fuel hose and the line.
(6) Install the starter air inlet duct support brace.
(7) Sparingly apply antiseize compound to the threads of the electrical harness receptacle and adjacent thermocouple receptacles. Connect the leads and secure the harness connector with lockwire.
(8) Connect the turbine discharge pressure pickup line from the engine to the line from the pressure ratio transducer.
(9) Connect the power control rod to the power control lever cross-shaft linkage at the threaded end disconnect.
(10) Inspect the engine installation for completeness.

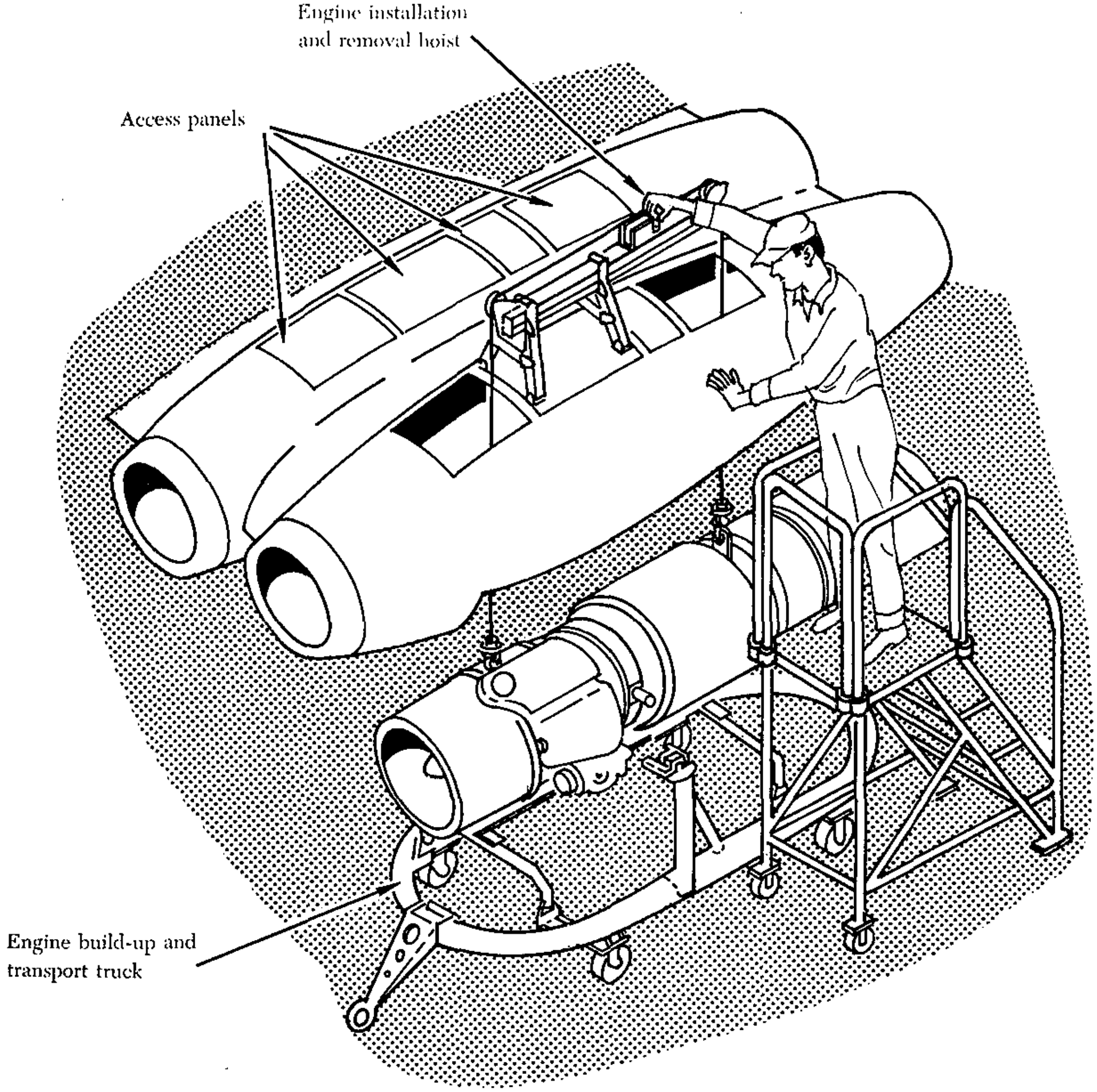


FIGURE 8–19. Installation with a two-cable hoist.

(11) Install the access covers.

(12) Adjust the power control linkage and trim the engine, if required. Close and secure the nacelle doors.

RIGGING, INSPECTIONS, AND ADJUSTMENTS

The following instructions cover some of the basic inspections and procedures for rigging and adjusting fuel controls, fuel selectors, and fuel shutoff valves.

(1) Inspect all bellcranks for looseness, cracks, or corrosion.

(2) Inspect rod ends for damaged threads and the number of threads remaining after final adjustment.

(3) Inspect cable drums for wear and cable guards for proper position and tension.

While rigging the fuel selector, power control, and shutoff valve linkages, follow the manufacturer's step-by-step procedure for the particular aircraft model being rigged. The cables should be rigged with the proper tension with the rigging pins installed. The pins should be free to be removed without any binding; if they are hard to remove, the cables are not rigged properly and should be re-checked. The power lever should have the proper cushion at the "idle" and "full-power" positions. The pointers or indicators on the fuel control should be within limits. The fuel selectors must be rigged so that they have the proper travel and will not restrict the fuel flow to the engines.

Rigging Power Controls

Modern turbojet aircraft use various power lever control systems. One of the common types is the cable and rod system. This system uses bellcranks, push-pull rods, drums, fair-leads, flexible cables, and pulleys. All of these components make up the control system and must be adjusted or rigged from time to time. On single-engine aircraft the rigging of the power lever controls is not very difficult. The basic requirement is to have the desired travel on the power lever and correct travel at the fuel control. But on multi-engine turbojet aircraft, the power levers must be rigged so that they are aligned at all power settings.

The power lever control cables and push-pull rods in the airframe system to the pylon and nacelle are not usually disturbed at engine change time and usually no rigging is required, except when some component has been changed. The control system from the pylon to the engine must be rigged after each engine change and fuel control change. Figure 8–20 shows the control system from the bellcrank in the upper pylon to the fuel control.

Before adjusting the power controls at the engine, be sure that the power lever is free from binding and the controls have full-throw on the console. If they do not have full-throw or are binding, the

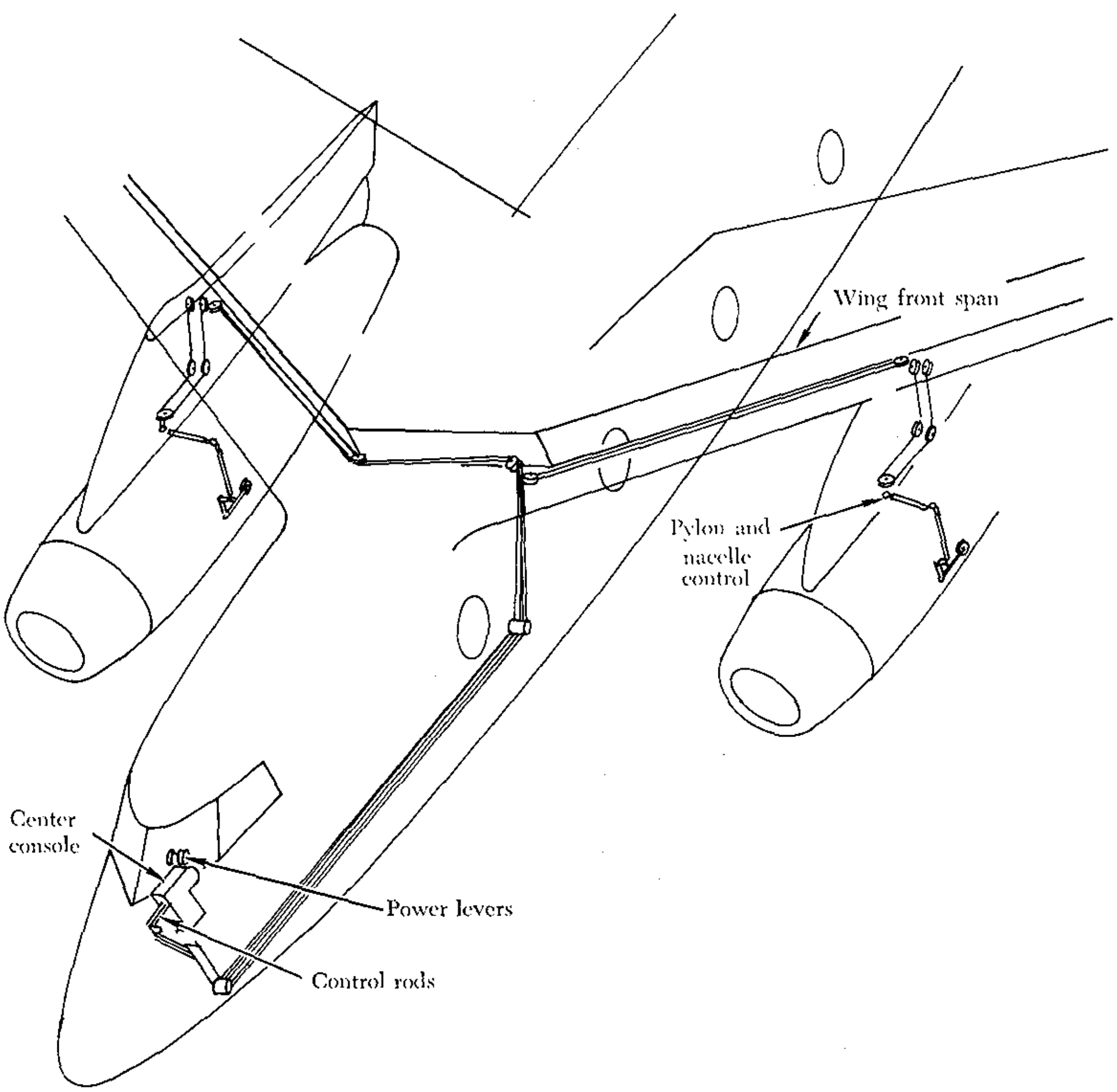


FIGURE 8–20. Power lever control system.

airframe system should be checked and the discrepancies repaired.

After all adjustments have been made, move the power levers through their complete range, carefully inspecting for adequate clearance between the various push-pull rods and tubes. Secure all locknuts, cotter pins, and lockwire, as required.

Adjusting the Fuel Control

The fuel control unit of the typical turbojet engine is a hydromechanical device which schedules the quantity of fuel flowing to the engine so that the desired amount of thrust can be obtained. The amount of thrust is dictated by the position of the power lever in the cockpit and the particular operation of the engine. Thus, the thrust of the engine and the consequent r.p.m. of its turbine are scheduled by fuel flow.

The fuel control unit of the engine is adjusted to trim the engine in order that the maximum thrust output of the engine can be obtained when desired. The engine must be re-trimmed when a fuel control unit is replaced or when the engine does not develop maximum thrust.

After trimming the engine, the idle r.p.m. can be adjusted. The idle r.p.m. is adjusted by turning the INC. IDLE screw an eighth of a turn at a time, allowing sufficient time for the r.p.m. to stabilize between adjustments. Retard the power lever to idle and re-check the idle r.p.m.

If wind velocity is a factor, the aircraft should be headed into the wind while trimming an engine. Since trimming accuracy will decrease as windspeed and moisture content increase, the most accurate trimming is obtained under conditions of no wind and clear, moisture-free air. No trimming should be done when there is a tailwind because of the possibility of the hot exhaust gases being re-ingested. As a practical matter, the engine should never be trimmed when icing conditions exist because of the adverse effects on trimming accuracy. To obtain the most accurate results, the aircraft should always be headed into the wind while the engine is being trimmed.

With the aircraft headed into the wind, verify that the exhaust area is clear. Install an engine trim gage to the T-fitting in the turbine discharge pressure line. Start the engine and allow it to stabilize for 5 minutes before attempting to adjust the fuel control. Refer to the applicable manufacturer's instructions for correct trim values. If the trim is not within limits, turn the INC. MAX screw (figure 8–21) about one-eighth turn in the appropriate direction. Repeat if necessary until the desired value is attained. If the aircraft is equipped with a pressure ratio gage, set it to the correct value.

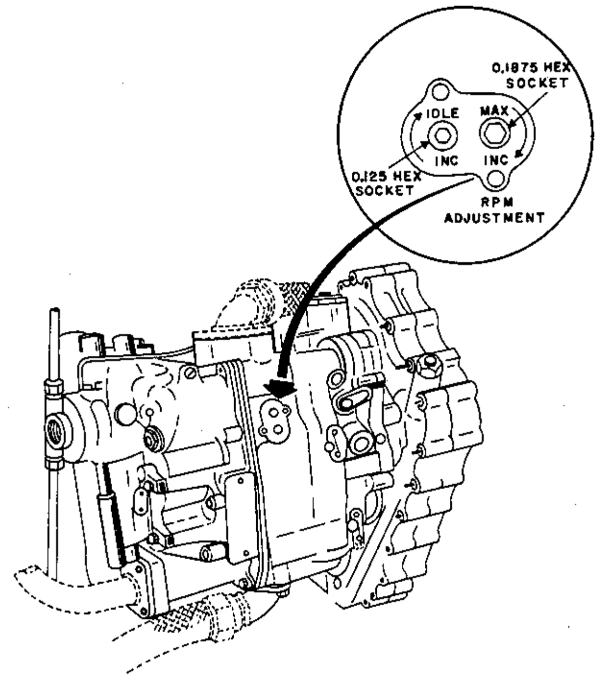


FIGURE 8–21. Typical fuel control adjustments.

TURBOPROP POWERPLANT REMOVAL AND INSTALLATION

The following information provides a general picture of a typical turboprop powerplant removal and installation.

Since most turboprop powerplant removal and installation instructions are developed for QECA, the following procedures reflect those used for a typical QECA. The procedures for turboprop engine removal and installation are similar to those presented in the section of this chapter for turbojet engines, except for those systems related to the turboprop propeller.

Open the engine side panels, and remove the nacelle access panels. Disconnect the engine thermocouple leads at the terminal board. Before disconnecting any lines, make sure that all fuel, oil, and hydraulic fluid valves are closed. Cap or plug all lines as they are disconnected to prevent entrance of foreign material.

Remove the clamps securing the bleed-air ducts at the firewall. Then disconnect the following: (1) Electrical connector plugs, (2) engine breather and vent lines, and (3) fuel, oil, and hydraulic lines.

Disconnect the engine power lever and propeller control rods or cables.

Remove the covers from the QECA lift points, attach the QECA sling and remove slack from the cables using a suitable hoist. The sling must be adjusted to position the hoisting eye over the QECA center of gravity. Failure to do so may result in engine damage.

Remove the engine mount bolts. The QECA is then ready to be removed. Recheck all of the disconnect points to make certain they are all disconnected prior to moving the engine. Move the engine forward, out of the nacelle structure, until it clears the aircraft. Lower the QECA into position on the QECA stand, and secure it prior to removing the engine sling.

The installation procedures are essentially the reverse of the removal procedures. Move the QECA straight back into the nacelle structure and align the mount bolt holes and the firewall. Start all the bolts before torquing. With all the bolts started, and using the correct torque wrench adapter, tighten the mount bolts to their proper torque. Remove the sling and install the access covers at the lift point. Using the reverse of the removal procedures, connect the various lines and connectors. New O-ring seals should be used. The manufacturer's instructions should be consulted for the proper torque limits for the various clamps and bolts.

After installation, an engine run-up should be made. In general the run-up consists of checking proper operation of the powerplant and related systems. Several functional tests are performed to evaluate each phase of engine operation. The tests and procedures outlined by the engine or airframe manufacturers should be followed.

HELICOPTER ENGINE REMOVAL AND INSTALLATION

An R1820 9-cylinder, air-cooled radial engine illustrates helicopter engine removal and installation procedures. The engine is installed facing aft with the propeller shaft approximately 39° above the horizontal.

The engine is supported by the engine mount (figure 8–22), which is bolted to the fuselage structure. The installation of the engine provides for ease of maintenance by allowing easy access to all accessories and components when the engine access doors are opened.

The QECA (figure 8–23) contains the engine, engine mount, engine accessories, engine controls, fuel system, lubrication system, ignition system,

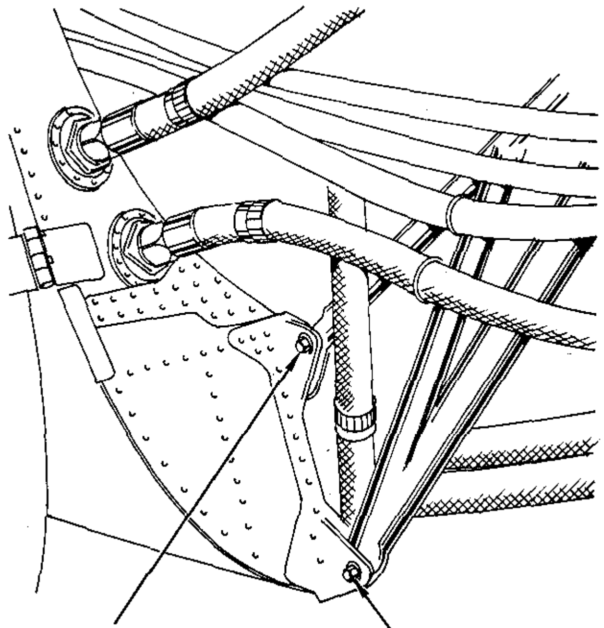


FIGURE 8–22. Engine mount attachment point.

cooling system, and hydromechanical clutch and fan assembly.

Removal of Helicopter QECA

Prior to removing the helicopter QECA, the engine should be preserved if it is possible to do so.

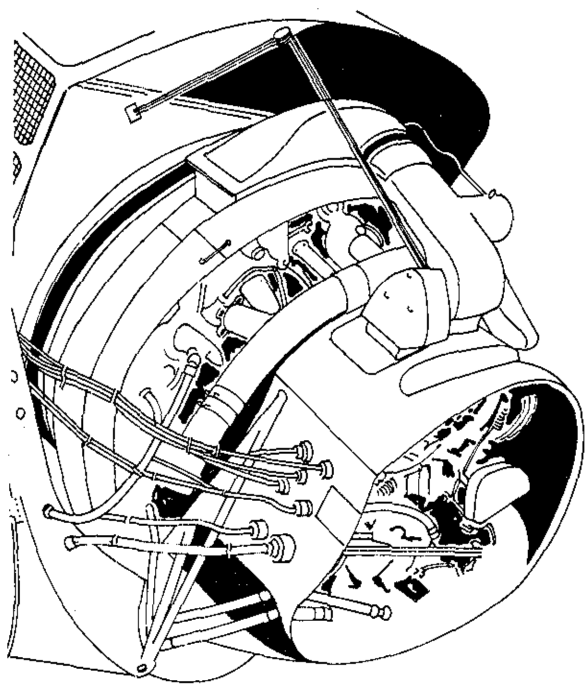


FIGURE 8–23. Typical helicopter QECA.

Then shut off the fuel supply to the engine and drain the oil. Make the disconnections necessary to remove the QECA, and then perform the following steps:

(1) Attach the engine lifting sling (figure 8–24). In this example, attach the two short cable fittings of the sling to the forward surface of the intake rocker boxes of Nos. 2 and 9 cylinders, and the two long cable fittings of the sling to the forward surface of the intake rocker boxes of Nos. 4 and 7 cylinders. Attach the sling to a hoist of at least a 2-ton capacity.

(2) Raise the hoist to apply a slight lift to the QECA. Loosen both engine mount lower attachment bolt nuts before leaving the upper attachment bolts.

(3) Remove the bolts from the sway braces and remove both engine upper attachment bolts. Then remove both engine mount lower attachment bolts and remove the QECA from the helicopter. Mount the power package in a suitable workstand and remove the sling.

Installation of Helicopter QECA

The installation of a new or an overhauled engine is in reverse of the removal procedure. The manufacturer's instructions for the helicopter must be consulted to ascertain the correct interchange of parts from the old engine to the new engine. The applicable maintenance instructions should be followed.

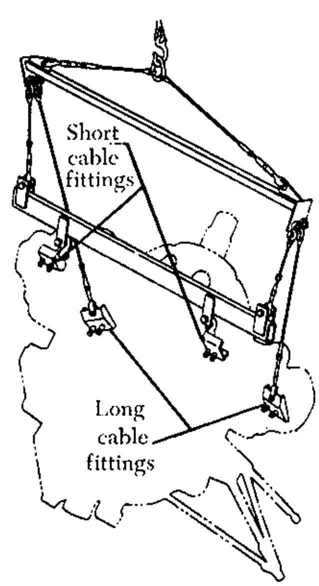


FIGURE 8–24. Special sling used for hoisting helicopter QECA.

RIGGING AND ADJUSTMENT OF HELICOPTER QECA

Throttle

Adjustment of a throttle control system consists of the following:

(1) Adjusting the QECA portion, which includes the control assembly above the carburetor and extends to the carburetor.

(2) Adjusting the airframe portion, which extends from the twist-grip and collective control to the control assembly.

(3) Adjusting the throttle limit switch. The QECA portion of the system can usually be adjusted with the power package removed from, or installed in, the helicopter.

Refer to the Maintenance Instructions Manual and associated technical publications for detailed information concerning cable tensions and related data.

Carburetor Mixture Control

Place the mixture lever on the control quadrant in the "normal" position, and move the mixture arm on the carburetor to the "normal" detent. Adjust the turnbuckle barrels inside the console in the cockpit to produce an equal amount of tension on each cable. Check the operation of the mixture control lever by moving it to the "idle cutoff" position and then into the "full rich" position for positive positioning of the mixture control.

Carburetor Air Temperature Control

Place the carburetor heat lever in mid-position. Adjust the turnbuckle barrels to produce an equal amount of tension on each cable and then lock-wire. Move the lever on the air intake duct to the mid-position, and adjust the actuating rod to meet the arm of the pulley assembly. Then secure the rod to the arm.

Testing the Engine Installation

Normal engine run-in procedures must be followed in accordance with the manufacturer's instructions. A flight test is usually performed after the engine has been installed and the engine controls have been adjusted.

ENGINE MOUNTS

Mounts for Radial Engines

All modern aircraft equipped with radial engines use an engine mount structure made of welded steel tubing. The mount is constructed in one or more sections that incorporate the engine mount ring, bracing members (V-struts), and fittings for attaching the mount to the wing nacelle.

The engine mounts are usually secured to the aircraft by special heat-treated steel bolts. The importance of using only these special bolts can be readily appreciated, since they alone support the entire weight of and withstand all the stresses imposed by the QECA.

The upper bolts support the weight of the engine while the aircraft is on the ground, but when the aircraft is airborne another stress is added. This stress is torsional and affects all bolts, not just the top bolts.

A close look at the typical engine mount ring shown in figure 8–25 will disclose fittings and attachments located at various positions on the engine mount structure. Each fitting performs a certain function.

The section of an engine mount where the engine is attached is known as the engine mount ring. It is usually constructed of steel tubing having a larger diameter than the rest of the mount structure. It is circular in shape so that it can surround the engine blower and accessory section, which is near the point of balance for the engine. The engine is usually attached to the mount by dynafocal mounts, attached to the engine at the point of balance forward of the mount ring. Other types of mounting devices are also used to secure the different engines to their mount rings.

As aircraft engines became larger and produced more power. some method was needed to absorb their vibration. This demand led to the development of the rubber and steel engine-suspension units called shock mounts. Because this combination permits restricted engine movement in all directions, these vibration isolators are commonly known as flexible, or elastic, shock mounts. An

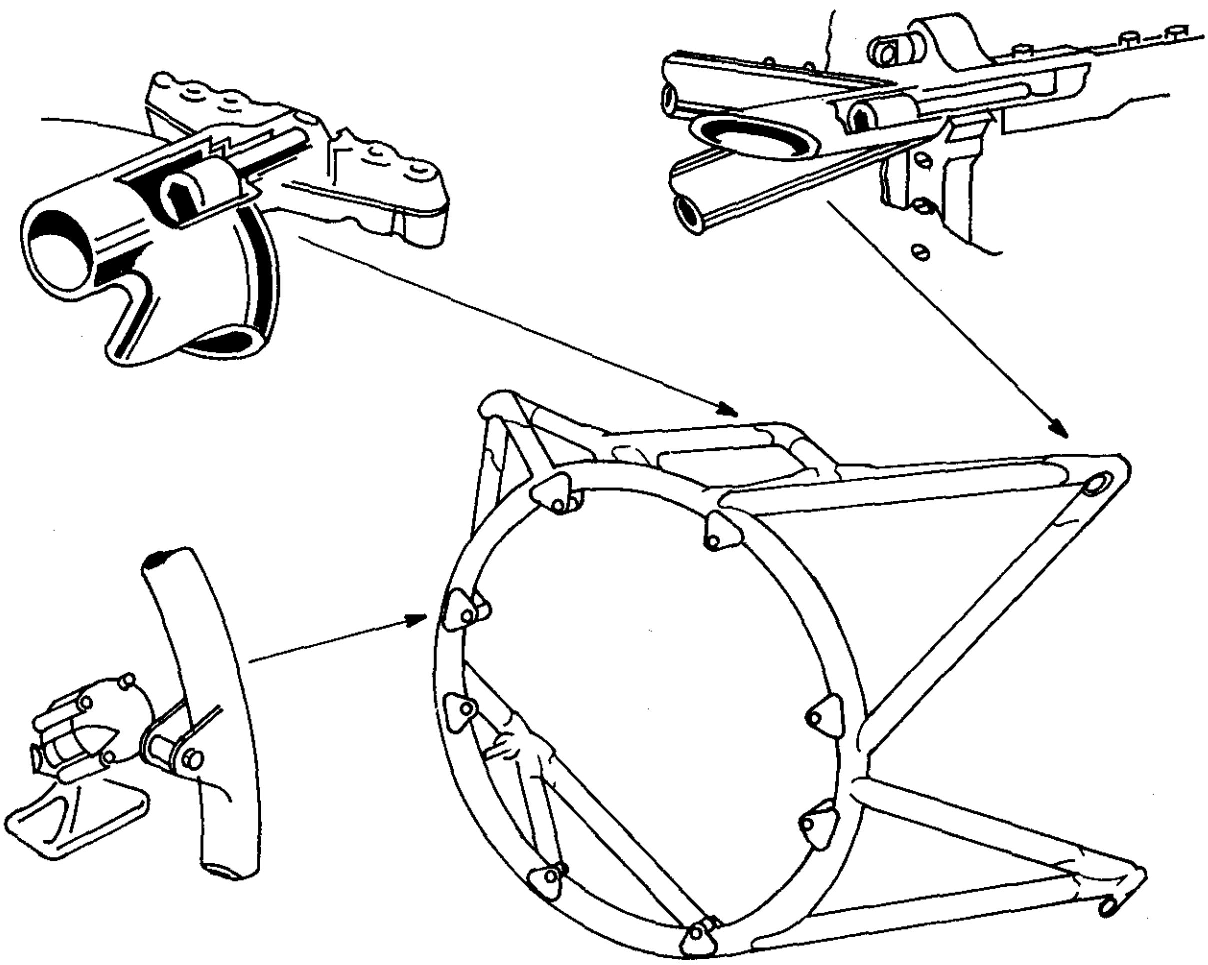


FIGURE 8–25. Typical engine mount.

interesting feature common to most shock mounts is that the rubber and metal parts are arranged so that, under normal conditions, rubber alone supports the engine. Of course, if the engine is subjected to abnormal shocks or loads, the metal snubbers will limit excessive movement of the engine.

Engine mounting suspensions for radial engines may be divided into two main groups: (1) The tangential-suspension type, and (2) the dynafocal type.

The tangential suspension, commonly called the tube-form mounting, is widely used for both in-line and radial engine support. A cutaway view of this type is shown in figure 8–26. This type of mounting is most flexible along its principal axis. Various

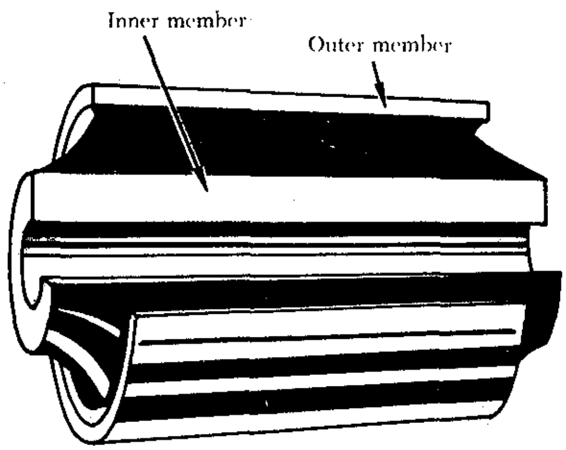


FIGURE 8–26. Tube-form engine mounting.

means of attachment are used in different installations using tube-form mountings.

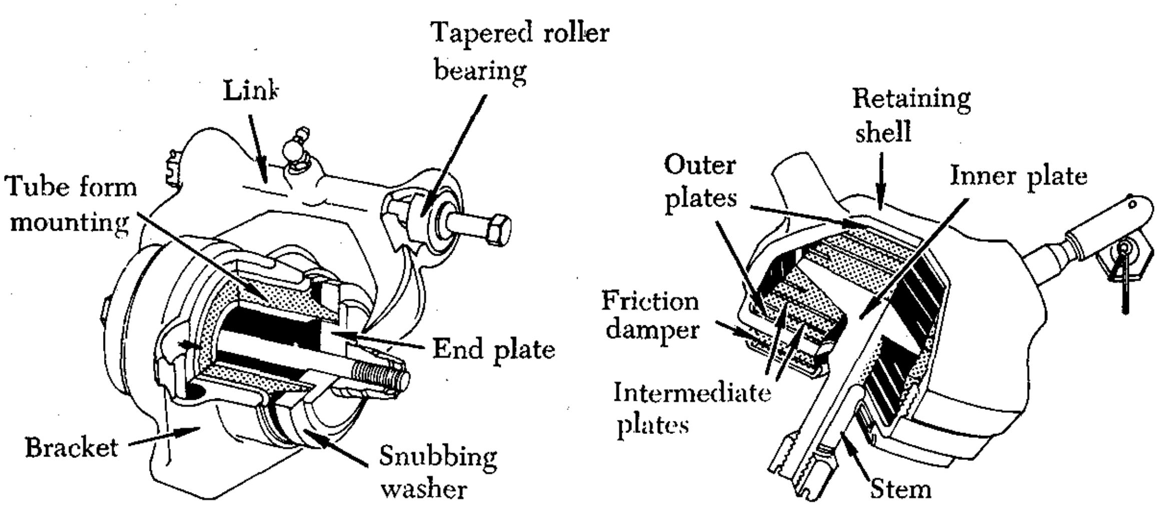
Dynafocal engine mounts, or vibration isolators, are units which give directional support to radial engines. Two of the most common types of dynafocal mounts are the link-type and the pedestal-type, shown in figure 8–27.

The link-type dynafocal mount uses a tube-form mounting for the flexible element. The outer member of this mounting is clamped into a forged bracket of aluminum alloy or steel and bolted rigidly to the engine mount pad or boss. The link is fitted with tapered roller bearings at the mounting-ring attachment points. Rubber snubbing washers with backing end plates are provided on both extensions of the inner member. These snubbing washers limit the axial motions of the mounting without allowing metal-to-metal contact between subassembly parts.

The pedestal-type dynafocal has an outer shell composed of two steel forgings fastened securely together and bolted to the mounting-ring structure. A predetermined amount of movement is allowed before the rubber is locked out of action by contact between the stem of the dynafocal and the retaining shell. Friction dampers are provided to limit excessive movement.

Mounts for Turbojet Engines

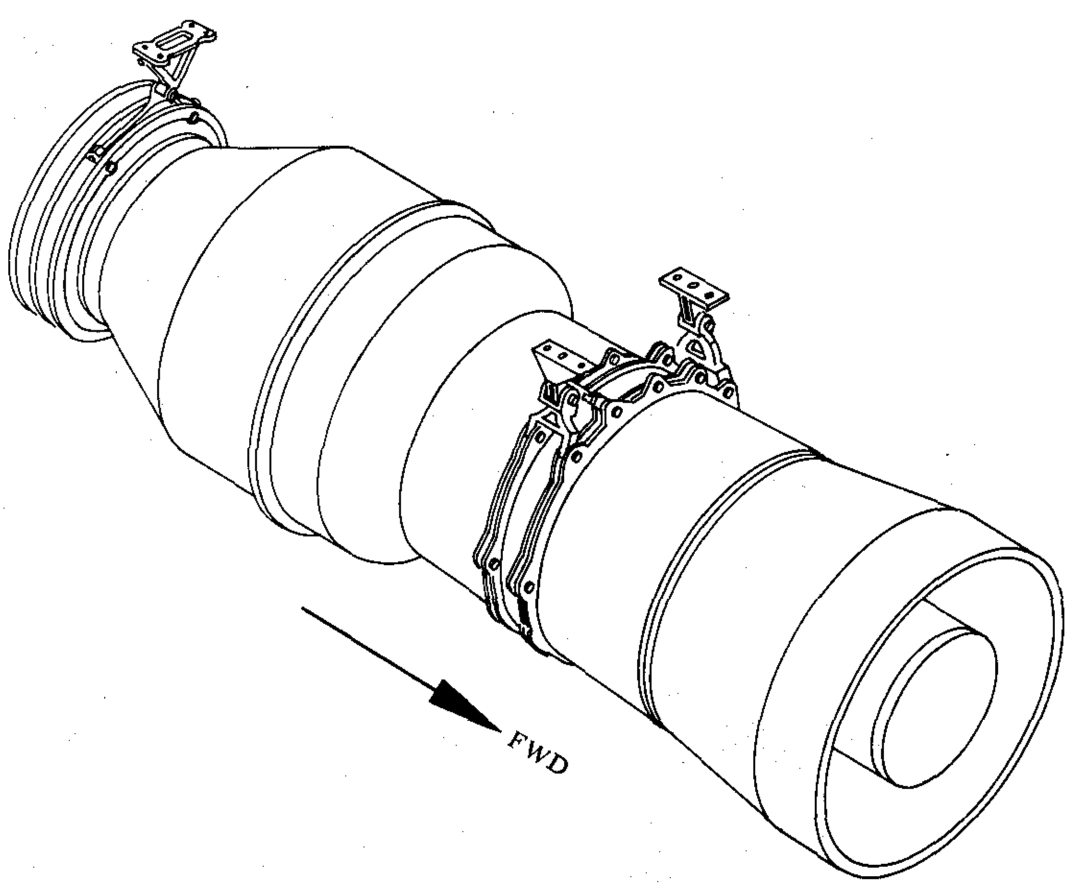
The engine mounts on most turbojet engines are relatively simple when compared with the mounting structures installed on reciprocating engines. However, they perform the same basic functions of



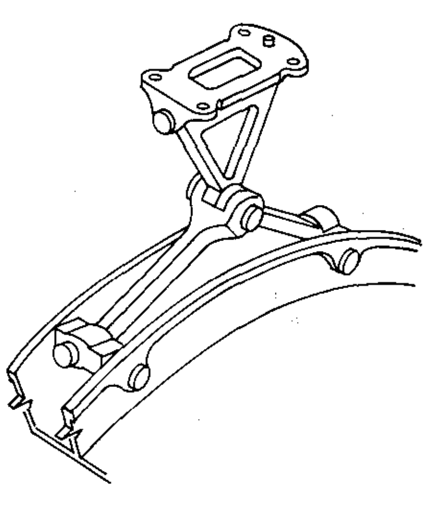
Link type dynafocal subassembly.

Pedestal-type dynafocal subassembly.

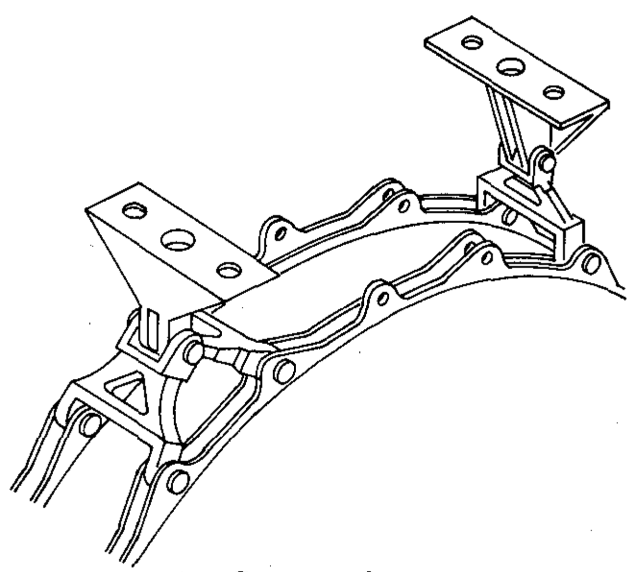
FIGURE 8–27. Two types of dynafocal mounts.



A. Engine mounts



B. Aft mount



C. Forward mounts

FIGURE 8–28. Typical turbine engine mounts.

supporting the engine and transmitting the loads imposed by the engine to the aircraft structure. Most turbine engine mounts are made of stainless steel, and are typically located as illustrated in figure 8–28. Some engine mounting systems use two mounts to support the rear end of the engine and a single mount at the forward end.

PRESERVATION AND STORAGE OF ENGINES

An engine awaiting overhaul or return to service after overhaul must be given careful attention. It does not receive the daily care and attention necessary to detect and correct early stages of corrosion. For this reason, some definite action must be taken to prevent corrosion from affecting the engine.

Corrosion-Preventive Materials

An engine in service is in a sense "self-purging" of moisture, since the heat of combustion evaporates the moisture in and around the engine, and the lubricating oil circulated through the engine temporarily forms a protective coating on the metal it contacts. If the operation of an engine in service is limited or suspended for a period of time, the engine is preserved to a varying extent, depending upon how long it is to be inoperative. This discussion is primarily directed to preserving engines that have been removed from an aircraft. However, the preservation materials discussed are used for all types of engine storage.

Corrosion-Preventive Compounds

Corrosion-preventive compounds are petroleum-base products which will form a waxlike film over the metal to which it is applied. Several types of corrosion-preventive compounds are manufactured according to different specifications to fit the various aviation needs. The type mixed with engine oil to form a corrosion-preventive mixture is a relatively light compound that readily blends with engine oil when the mixture is heated to the proper temperature.

The light mixture is available in three forms: MIL–C–6529 type I, type II, or type III. Type I is a concentrate and must be blended with three parts of MIL–L–22851 or MIL–L–6082, grade 1100 oil to one part of concentrate. Type II is a ready-mixed material with MIL–L–22851 or grade 1100 oil and does not require dilution. Type III is a ready-mixed material with grade 1010 oil, for use in turbine engines only. The light mixture is intended for use when a preserved engine is to remain inactive for less than 30 days. It is also used to spray cylinders and other designated areas.

The desired proportions of lubricating oil and either heavy or light corrosion-preventive compound must not be obtained by adding the compound to the oil already in the engine. The mixture must be prepared separately before applying to the engine, or placing in an oil tank.

A heavy compound is used for the dip treating of metal parts and surfaces. It must be heated to a high temperature to be sufficiently liquid to effectively coat the objects to be preserved. A commercial solvent or kerosene spray is used to remove corrosion-preventive compounds from the engine or parts when they are being prepared for return to service.

Although corrosion-preventive compounds act as an insulator from moisture, in the presence of excessive moisture they will eventually break down and corrosion will begin. Also, the compounds eventually become dried because their oil base gradually evaporates. This allows moisture to contact the engine's metal, and aids in corroding it. Therefore, when an engine is stored in a shipping case or container, some dehydrating (moisture removing) agent must be used to remove the moisture from the air in and around the engine.

Dehydrating Agents

There are a number of substances (referred to as desiccants) that can absorb moisture from the atmosphere in sufficient quantities to be useful as dehydrators. One of these is silica gel. This gel is an ideal dehydrating agent since it does not dissolve when saturated.

As a corrosion preventive, bags of silica gel are placed around and inside various accessible parts of a stored engine. It is also used in clear plastic plugs, called dehydrator plugs, which can be screwed into engine openings such as the spark plug holes. Cobalt chloride is added to the silica gel used in dehydrator plugs. This additive makes it possible for the plugs to indicate the moisture content or relative humidity of the air surrounding the engine. The cobalt-chloride-treated silica gel remains a bright blue color with low relative humidities; but as the relative humidity increases, the shade of the blue becomes progressively lighter, becoming lavender at 30% relative humidity and fading through the various shades of pink, until at 60% relative humidity it is a natural or white color. When the relative humidity is less than 30%, corrosion does not normally take place. Therefore, if the dehydrator plugs are bright blue, the air in the engine has so little moisture that internal corrosion will be held to a minimum.

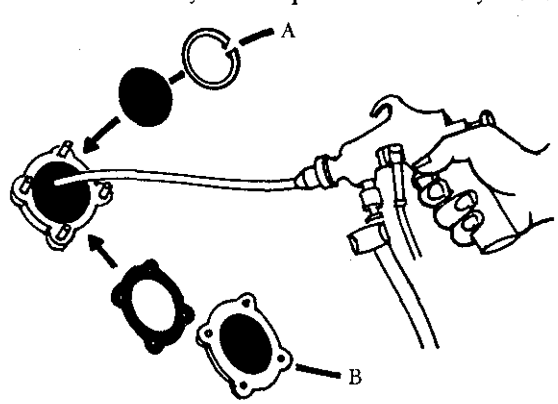
This same cobalt-chloride-treated silica gel is used in humidity indicator envelopes. These envelopes can be fastened to the stored engine so that they can be inspected through a small window in the shipping case or metal engine container.

All desiccants are sealed in containers to prevent their becoming saturated with moisture before they are used. Care should be taken never to leave the container open or improperly closed.

CORROSION-PREVENTIVE TREATMENT

Before an engine is removed it should be operated, if possible, with corrosion-preventive mixture added in the oil system to retard corrosion by coating the engine's internal parts. If it is impossible to operate the engine before removal from the aircraft, it should be handled as much as possible in the same manner as an operable engine.

Any engine being prepared for storage must receive thorough treatment around the exhaust ports. Because the residue of exhaust gases is potentially very corrosive, a corrosion-preventive mixture must be sprayed into each exhaust port, including the exhaust valve. After the exhaust ports have been thoroughly coated, a moistureproof and oilproof gasket backed by a metal or wooden plate, should be secured over the exhaust ports using the exhaust stack mounting studs and nuts (figure 8–29). These covers form a seal to prevent moisture from entering the interior of the engine through the exhaust ports. Engines stored in metal containers usually have special ventilatory covers



A. Ventilator cover

B. Oilproof and moistureproof seal

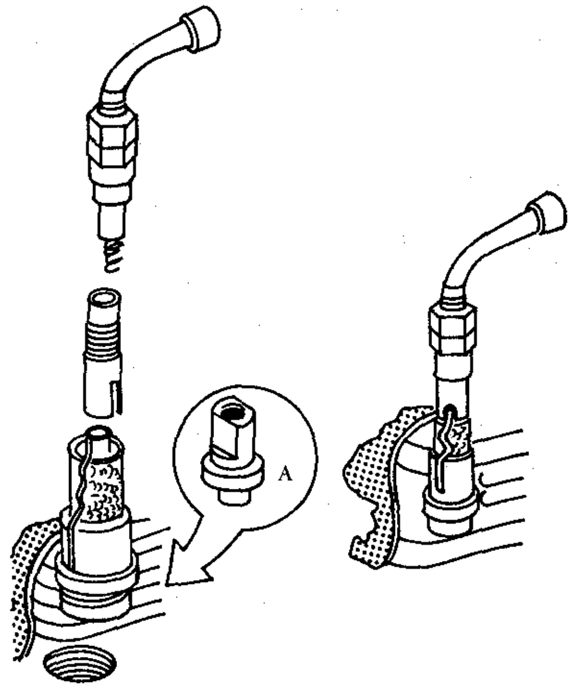
FIGURE 8–29. Treating and sealing the exhaust ports.

To prevent corrosion, spray each cylinder interior with corrosion-preventive mixture to prevent moisture and oxygen from contacting the deposits left by combustion. Spray the cylinders by inserting the nozzle of the spray gun into each spark plug hole and "playing" the gun to cover as much area as possible. Before spraying, each cylinder to be treated should be at the "bottom center" position. This allows the entire inside of the cylinder to become coated with corrosion-preventive mixture. After spraying each engine cylinder at "bottom center," re-spray each cylinder while the crankshaft is stationary.

The crankshaft must not be moved after this final spraying, or the seal of corrosion-preventive mixture between the pistons and cylinder walls will be broken. Air can then enter past the pistons into the engine. Also, the coating of corrosion-preventive mixture on the cylinder walls will be scraped away, exposing the bare metal to possible corrosion. Until it is safely stored in the shipping case, the engine should have a sign attached similar to the following: "DO NOT TURN CRANKSHAFT."

When preparing the engine for storage, dehydrator plugs are screwed into the spark plug opening of each cylinder. If the engine is to be stored in a wooden shipping case, the ignition harness leads are attached to the dehydrator plugs with lead supports, as shown in figure 8–30. Special ventilatory plugs (figure 8–30) are installed in the spark plug holes of an engine stored horizontally in a metal container. If the engine is stored vertically in a container, these vent plugs are installed in only the upper spark plug holes of each cylinder, and nonventilatory plugs are installed in the lower cylinders. Dehydrator plugs from which the desiccant has removed may be used for this latter purpose.

Another point at which the engine must be sealed is the intake manifold. If the carburetor is to remain on the engine during storage, the throttle valve should be wired open and a seal installed over the air inlet. But, if the carburetor is removed and stored separately, the seal is made at the carburetor mounting pad. The seal used in either instance can be an oilproof and moistureproof gasket backed by a wooden or metal plate securely bolted into place. Silica gel should be placed in the intake manifold to absorb moisture. The silica gel bags are usually suspended from the cover plate. This eliminates the possibility of forgetting to remove the silica gel bags when the engine is eventually



A. Ventilator plug

FIGURE 8–30. Ignition harness lead support installation.

removed from storage. A ventilatory cover without silica gel bags attached can be used when the engine is stored in a metal container.

After the following details have been taken care of, the engine is ready to be packed into its container. If the engine has not been spray coated with corrosion-preventive mixture, the propeller shaft and propeller shaft thrust bearing must be coated with the compound. Then, a plastic sleeve, or moistureproof paper is secured around the shaft, and a threaded protector cap is screwed onto the propeller retaining nut threads.

All engine openings into which dehydrator plugs (or ventilatory plugs if the engine is stored in a metal container) have not been fitted must be sealed. At points where corrosion-preventive mixture can seep from the interior of the engine, such as the oil inlet and outlet, oilproof and moistureproof gasket material backed by a metal or wooden plate should be used. At other points moistureproof tape can be used if it is carefully installed.

Before its installation in a shipping container, the engine should be carefully inspected to determine if the following accessories, which are not a part of the basic engine, have been removed: Spark plugs and spark plug thermocouples, remote fuel pump adapters (if applicable), propeller hub attaching bolts (if applicable), starters, generators, vacuum pumps, hydraulic pumps, propeller governors, and engine-driven fuel pumps.

ENGINE SHIPPING CONTAINERS

For protection, engines are sealed in plastic or foil envelopes and packed in a wooden shipping case. In recent years the practice of sealing aircraft engines in pressurized metal containers has been increasingly adopted.

When a radial engine is installed in a wooden shipping case, it must be hoisted vertically, with the propeller end up. This necessitates the use of two hoists, as shown in figure 8–31.

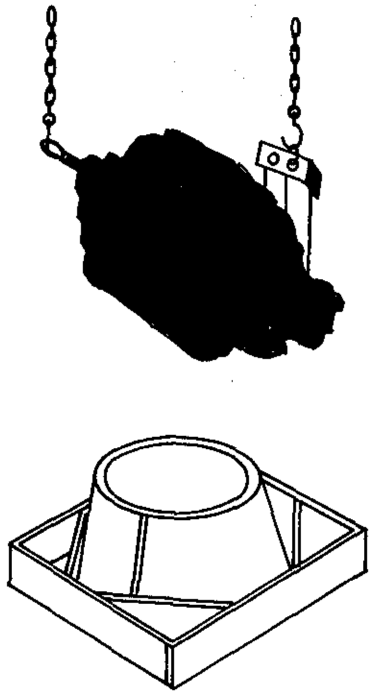
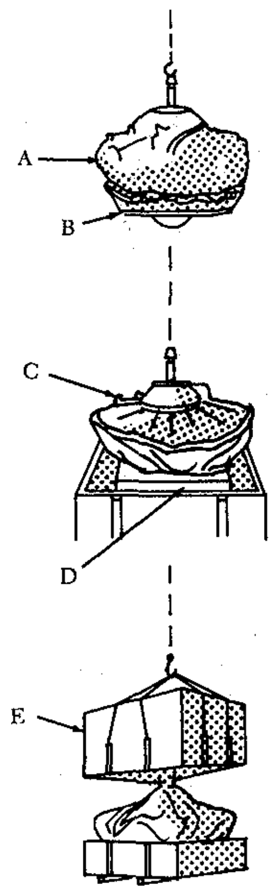


FIGURE 8–31. Hoisting engine for vertical packing.

While the engine is suspended above the base of the shipping case, the mounting plate (figure 8–32) is removed from the case, and the grommets of the protective envelope in which the engine is sealed are fitted to the anchor bolts of the mounting plate. The mounting plate is then bolted to the engine, and the envelope carefully pulled up around the engine.

The engine is then lowered onto the base of the shipping case so that the mounting plate can be bolted into position. Since a mounting ring is used only for radial engines, the protective envelope is attached directly to the base of the shipping case for other types of engines. Then the engine is lowered vertically onto the base and bolted directly to it.



A. Engine
B. Mounting plate
C. Protective envelope
D. Pedestal
E. Cover

FIGURE 8–32. Preparing engine for packing.

If the carburetor is not mounted on the engine or no provision is made to seal it in a small container to be placed inside the shipping case, it can, in some cases, be fastened to a specially constructed platform bolted to the engine.

Before the protective envelope is sealed, silica gel should be placed around the engine to dehydrate the air sealed into the envelope. The amount of silica gel used is determined by the size of the engine. The protective envelope is then carefully gathered around the engine and partially sealed, leaving an opening at one end from which as much air as possible is exhausted. A tank-type vacuum cleaner is very useful for this purpose and is also an aid in detecting any leaks in the envelope. The envelope is then completely sealed, usually by pressing the edges together and fusing them with heat.

Before lowering the shipping case cover over the engine, a quick inventory should be made. Be sure the humidity indicator card is placed so that it can be seen through the inspection window, and that everything required is enclosed in the container.

While lowering the wooden shipping case cover into position, be careful that it does not twist and tear the protective envelope. Secure the cover and stencil or mark the date of preservation on the case. Also, indicate whether the engine is repairable or serviceable.

There are several types of metal shipping containers in use. One model, shown in figure 8–33, is like the wooden shipping case in that it requires the engine to be installed from a vertical position.

Another type allows horizontal installation of an engine, thus eliminating the need for an extra hoist.

The engine is simply lowered onto the base portion of the container and secured. Then silica gel bags are packed into the container, usually in a special section. The amount of silica gel required in a metal container is generally greater than that needed in a wooden shipping case, since the volume

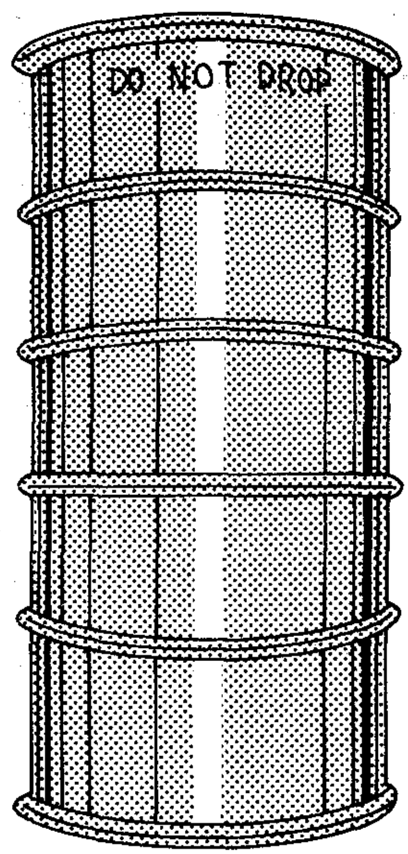


FIGURE 8–33. Metal container designed for vertical installation of engine.

of air in the metal container is much greater than that in the protective envelope installed around an engine in a wooden shipping case. Also, in the metal container the silica gel bags must dehydrate the interior of the engine, since ventilatory plugs are normally installed in the engine openings in place of dehydrator plugs.

All records of the engine should be enclosed inside the shipping container or on the outside for accessibility.

A humidity indicator should be fastened inside the containers with an inspection window provided. Then the rubber seal between the base and the top of the container must be carefully inspected. This seal is usually suitable for re-use several times. After the top of the container has been lowered into position and fastened to the base of the container, dehydrated air at approximately 5 p.s.i. pressure is forced into the container. The container should be checked for leaks by occasional re-checks of the air pressure, since radical changes in temperature affect the air pressure in the container.

INSPECTION OF STORED ENGINES

Most maintenance shops provide a scheduled inspection system for engines in storage. Normally, the humidity indicators on engines stored in shipping cases are inspected every 30 days. When the protective envelope must be opened to inspect the humidity indicator, the inspection period may be extended to once every 90 days, if local conditions permit. The humidity indicator of a metal container is inspected every 180 days under normal conditions.

If the humidity indicator in a wooden shipping case shows by its color that more than 30% relative humidity is present in the air around the engine, all desiccants should be replaced. If more than half the dehydrator plugs installed in the spark plug holes indicate the presence of excessive moisture, the interior of the cylinders should be re-sprayed. If the humidity indicator in a metal container gives a safe blue indication, but air pressure has dropped below 1 p.s.i., the container needs only to be brought to the proper pressure using dehydrated air. However, if the humidity indicator shows an unsafe (pink) condition, the engine should be re-preserved.

PRESERVATION AND DE-PRESERVATION OF GAS TURBINE ENGINES

The procedures for preserving and de-preserving gas turbine engines vary depending upon the length of inactivity, the type of preservative used, and whether or not the engine may be rotated during the inactive period. Much of the basic information on corrosion control presented in the section on reciprocating engines is applicable to gas turbine engines. However, the requirements in the use and types of preservatives are normally different.

The lubrication system is usually drained, and may or may not be flushed with preservative oil. Some engine manufacturers recommend spraying oil in the compressor while "motoring" the engine. Others caution against this practice. Always follow the manufacturer's instructions when performing any preservation or de-preservation of gas turbine engines.